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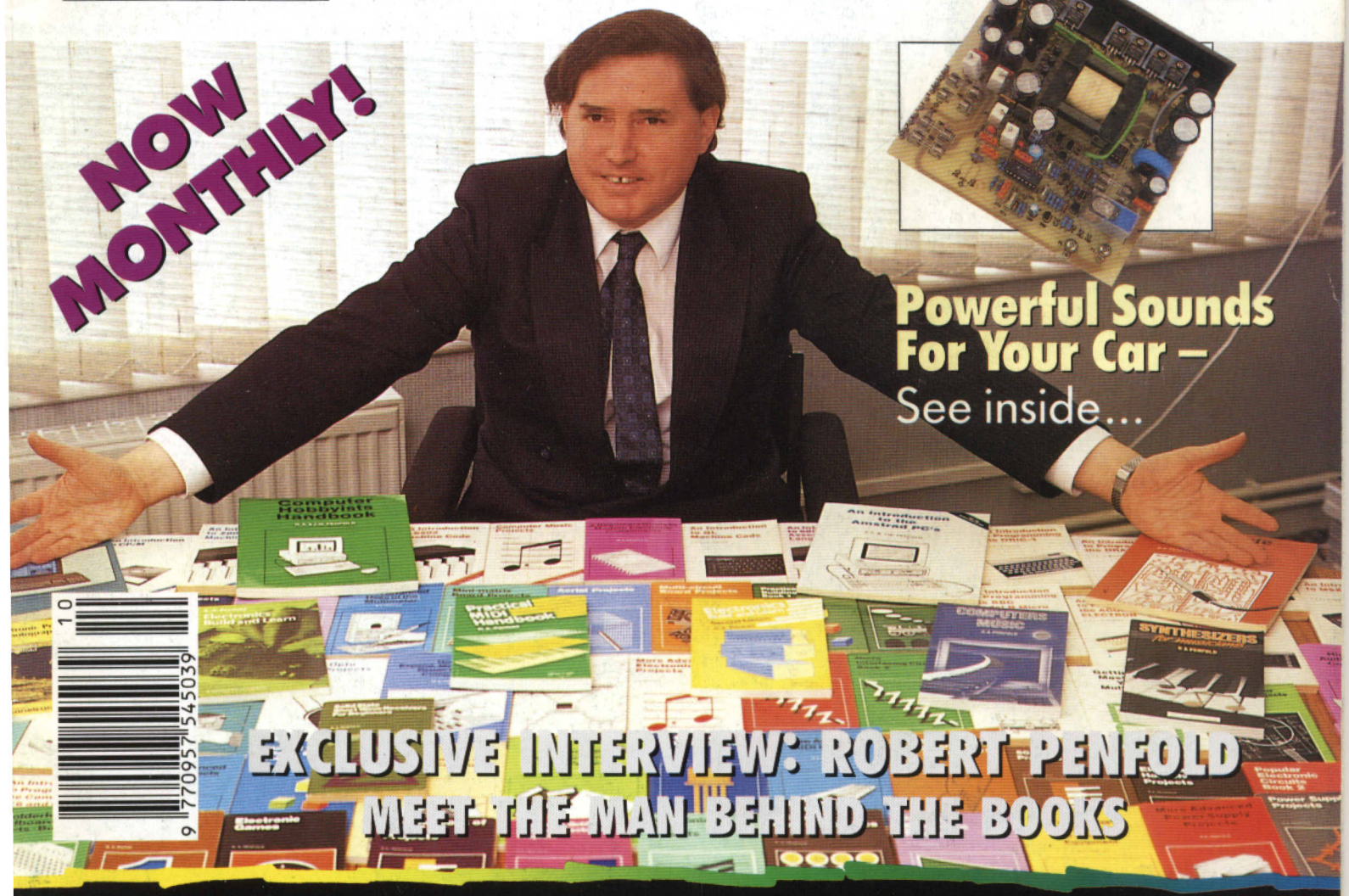
No. 46

ELECTRONICS

The Maplin Magazine

OCTOBER 1991 £1.60



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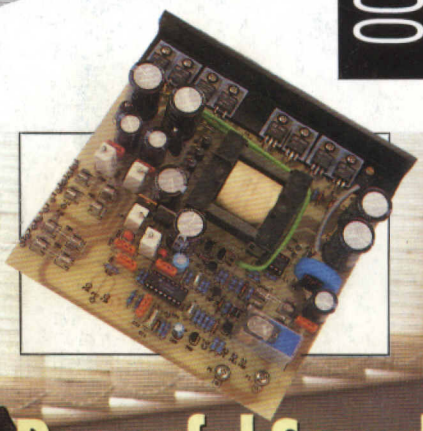

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OCTOBER 1991 VOL.10 No.46

EDITORIAL

Welcome to the first MONTHLY issue of 'Electronics'! I've kept the same popular recipe of projects and features that has made 'Electronics' Britain's best selling electronics magazine, only now you won't have to wait two months for the next issue!

An exclusive interview with the famous electronics author, Robert Penfold, reveals some little known facts about him and his books. Plus the chance to win ten of his best selling books, all personally autographed!

There are some really superb projects this month; a switched mode power supply that allows conventional power amplifiers to be used in a car. Also a compact car alarm that incorporates many features for its small size. The Galactic Timer project comes to a close, with a triac control card that interfaces the main unit to mains appliances. For the MIDI orientated musician there's a handy switch box. The L200 regulator IC is dealt with in Data File – ideal as a basis for a simple bench power supply. A very popular project over the years has been the CMOS Logic Probe – so much so the mould for the box wore-out! We've updated the project and included a new box design for easier construction.

There's all the usual features and regulars as well, so I hope you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

ABC 33,837

Editor Robert Ball. **Project Development** Chris Barlow, Gavin Cheeseman, Tony Bricknell, Alan Williamson. **Technical Author** Mike Holmes. **Consultant Author** Alan Simpson. **Technical Illustrators** Paul Evans, Lesley Foster, Ross Nisbet. **Production Co-ordinator** Alan Wraight. **Print Co-ordinator** John Craddock. **Advertising Co-ordinator** Kathy Peters. **Publications Manager** Roy Smith. **Development Manager** Dave Goodman. **Advertising Manager** Vic Sutton. **Drawing Office Manager** John Dudley. **Art Directors** Peter Blackmore, Jim Bowler. **Layout Artists** Graham Smith, Jamie Bishop. **Typesetters** Brian Lauezzari, Martin Needs. **Published by** Maplin Electronics Plc. **Typesetting and Production** Inline Design Systems Ltd, 258a London Road, Hadleigh, Essex SS7 2DE. **Colour Separations** Stirling Graphics Ltd., 16-22 West Street, Southend, Essex SS2 6HJ. **Printed by** Severn Valley Press, Caerphilly, Mid Glam CF83 3SU. **Distributed by** United Magazine Distribution Ltd., 1-11 Benwell Rd, London N7 7AX. **Mail Order** P.O. Box 3, Rayleigh, Essex SS6 8LR. **Retail Sales:** (0702) 554161. **Retail Enquiries:** (0702) 552911. **Trade Sales:** (0702) 554171. **Cashtel: (MODEM)** (0702) 552941. **General:** (0702) 554155. **Fax:** (0702) 553935. **Telex:** 995695.

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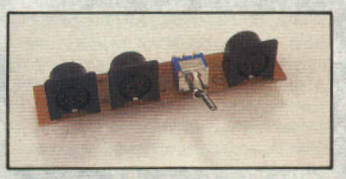
PROJECTS

4 2-WAY MIDI SWITCH BOX



A low-cost switch box that allows MIDI data-streams to be selected or routed.

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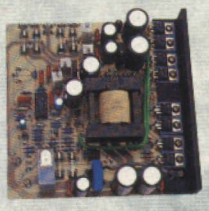

A superb project, allows Hi-Fi quality, high power amplifiers to be used in-car.

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CORRIGENDA

April to May 1991 Vol.10 No. 43
Data File: SSM2045
Page 5, Table 1 shows VCA gain in μs which is the abbreviation for 'micro seconds', this should actually read μS or 'micro siemens'.

June to July 1991 Vol. 10 No. 44
Video Amplifier
Page 49, Figure 1, circuit diagram shows C5 as being 68pF whilst the correct value is 470pF; R19, 20, 21 and 22 are shown as being 68k whilst the correct value is 68Ω. Figure 2, PCB legend shows C7 as being C8, this is also incorrect on the actual PCB. Figure 3, source selection table 2nd line reads 0, 01 RGB Input, whereas it should read 0, 1 RGB Input.
Page 52, Optional Parts List 6th line reads Phono socket twin 1 (JK15R), whereas it should read Phono socket single 1 (JH93B). Video Amplifier Parts List – Resistors last line reads R19, 22 68Ω 2, whereas it should read R19-22 68Ω 4. Capacitors 2nd line reads C2, 4 10μF 16V PC Electrolytic 2, whereas it should read C2–4 10μF 16V PC Electrolytic 3. 3rd line reads C5 68pF 1, whereas it should read C5 470pF 1.

Prices shown in this issue include VAT at 17.5% (except items marked 'A' which are rated at 0%) and are valid between 1st September 1991 and 31st December 1991.

NEWS Report

More TV – More Jobs

Backing its belief that gloom in the TV market-place is misplaced, particularly where new technology commands a price premium, Japanese television manufacturing company Sony has announced plans to build a multi-million pound, high technology factory in Wales. The £147m development will include production facilities for colour televisions and computer display monitors, a research and development centre and a multipurpose sports facility.
Already well established in the UK, the new facility will provide some 1,400 jobs in an area of high unemployment.

Not that any Sony TV sets apply, but the BBC is test marketing an extended warranty insurance for television sets which will extend the manufacturer's guarantee to five years for a single payment of £60. Features of the BBC 'Telecover' service include a guaranteed next day repair call, a replacement set if the receiver has to go away for repair, and direct payment of the repair bill, so that the customer does not have to pay and wait for reimbursement. All profits from this BBC Enterprise activity will be reinvested in new BBC programme productions, so helping to reduce the pressure on the licence fee.
Details: BBC 081-576 2339.

Networks Go Underground

Transpac Network Services have taken a shortcut into the UK by acquiring the London Regional Transport, extensive private X·25 based network CentreNet. Transpac, part of France Telecom, runs the world's most successful X·25 data communications service which includes the popular French Minitel Service. The move into the UK is seen by Transpac as being a major step towards the establishment of a pan-European data network with international communications to the rest of the world. According to Fred Metzgen who heads the UK operation, Transpac is keenly seeking further outsourcing opportunities. Also being announced today is the news that Maritime Cargo Processing is planning to link to the Transpac network later this year – initially within the M25 motorway region but as the network expands into national and international networks. The UK network which is supported by Alcatel, will have an operating capability in excess of 256Kbps as compared to the existing X·25 networks which operate at 64Kbps. As for those Minitel terminals, reliable sources are suggesting that unlike France where most terminals are given away, in the UK they will sell at about £165 each.

Driving Range

Having problems with your golf swing, or putting? With over 1500 different golf sets available, selecting the right club is not easy. Well, you need suffer no more dangerous liaisons with your golf club. Yes, high technology has arrived on the scene, in the shape of a computer. The US system allows players to find a club which exactly matches their requirements.
Swing away boys. Details: Southport Golf Complex, 0704 544312.

Flying High

At the recent Cable and Satellite Show 91, Swift Television Publications were giving away 3-coloured PVC window stickers – 'Satellite Installers do it with their parabolics'. Apparently the stickers proved so popular that the company had to have a further reprint. Call them on 0793 750620 if you want more details on how to get a free sticker.

Overtaken by Events

As the leading industry publication 'TRR' comments "It was almost inevitable that one or more of the four Telepoint operators would go. It is apparent that the market has judged CT2 to be the wrong product and the wrong time." Or, to be more blunt, CT2 has been overtaken by higher technological events.
Geoff Vincent of the PA Consulting Group is even more positive. "Telepoint has the image of being a total flop in the UK. Such a new technology should have been nurtured rather than thrown open to market forces. The governments' launch of the two-way calling PCN in mid development, effectively killed the 'making calls' only Telepoint technology at birth."

IBM Bites The Apple

Top news of the month – if not the year – must be the news that Apple Computers and IBM are working together to create powerful new open system software platforms for the late 1990s. The companies will develop and market new technologies which both Apple and IBM will integrate into existing and future products, as well as offering them for use on other vendor's computers.
Motorola will develop a new version of the IBM chip set and manufacture the chips for Apple and IBM as well as other companies wishing to market compatible systems. Whether the Apple/IBM pact will end as a happy family remains to be seen. One industry commentator, Michael Naughton of the international consultancy Applied Network Research, says that the historic deal will find it tough going to produce the best open operating system. It is clear though, says ANR, that Microsoft could find itself frozen out of the next generation of desktop computing markets while Intel, as the dominant microprocessor vendor, will find its market for high level PCs and workstations under pressure. At the same time IBM and Apple plan to work together to create and licence platform-independent multimedia software.

Boats, Railways and Planes

The Commission of The European Communities have been taking a look at the European transport system, and it doesn't like what it sees. Present transport networks are inadequate in relation to the present economic and social activities, with widespread traffic jams, overcrowding and deterioration of beauty spots and pollution. There is, says the EEC, an impending crisis looming.

For a start, the Commission has itself commissioned an independent inquiry into the development of a new breed of supersonic aircraft, and 800 seat 'planes, twice as big as the Boeing 747 'Jumbo'. At the same time, Europe's railway operators, including British, French and German railways have come together to build a continent-wide telecommunications network to help speed the traffic. Hopefully BR will be putting as much effort into linking the Euro-Tunnel with a TGV-type track.

Meanwhile, the ferries sail on serenely. The on-board ambience generated during a recent cross channel Sea Link voyage would have done credit to a mini ocean liner. Not only were the girls serenaded on board by rival teams of singers, but were handed roses at the completion of the trip. Euro-Tunnel take note.

Big Business

According to a recent report, the world telecommunications market will grow by more than a third between now and 1994. The United States will account for nearly half the total, with Western Europe taking nearly one third. Today's worldwide revenues from telecommunication network services is estimated at well over £180 billion a year. It is hardly surprisingly therefore that the France Telecoms company, Transpac Network Services has set up shop in the UK. Though whether the company will be issuing free Minitel terminals has not been revealed. BT and Mercury – you have been warned.

Planning for Tomorrow – Today

IBM may not be breaking any sales records at present, but there is no lack of corporate research activity in the back offices. IBM has recently unwrapped the world's fastest multichip ceramic package which speeds electricity between computer chips at the breakneck speed of 280 million miles per hour. A feat which no doubt would have more than somewhat impressed the subjects of this month's 'Out and About' feature – Messrs Babbage and Faraday.

The IBM package holds 121 silicon chips inside a densely packed ceramic module. To take advantage of the increasing speed of computer chips, computer architects must design equally speedy connections between the chips. The new five-inch-square package is currently in production as part of IBM's new system/390 series of large computers.

IBM scientists are reportedly a step closer to developing an instant camera that produces holograms, or an optical storage device that can hold up to a 100 million bits of information in a single spot, the size of the head of a pin, or goggles that automatically diffuse intense light to protect their wearers from being blinded by lasers. The secret is the discovery of a polymer which has an optical characteristic previously found in only a few small, expensive crystals. The polymer – a mixture of a new type of epoxy and an organic material used in copiers and laser printers – is the first to exhibit the 'photo-refractive' effect. That is, illumination by light causes electrical charges within the material to move, altering its index of refraction, the optical characteristic that affects how light passes through a material.

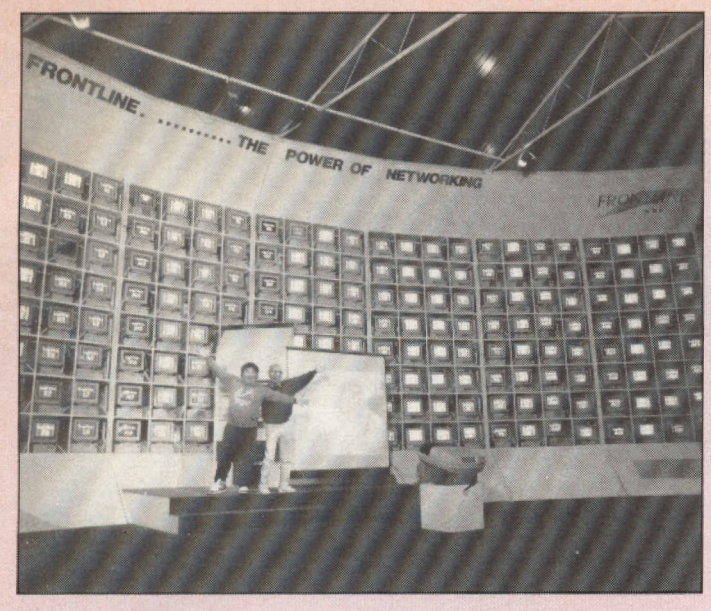
US Gets the PC Message

The news that computers can be found in some 14m US households has inspired President Bush to take his first hesitant steps into computing. Having found the on-off switch, he apparently fired up his first program. "It is never to late to learn", he said.

On a more global front, the publication *Octagon Alert* reports that there are an estimated 72m IBM PCs and IBM compatibles in current use in the world today. As the newsletter says, there must be a huge market out there for IBM PC applications software.

Blame the Computer

It doesn't just happen in the UK apparently. According to the daily industry publication 'Computergram', a house tenant in Le Havre, France, received a demand for one centime – about one tenth of a penny – in unpaid rent. However the kind computer, not wishing to inflict financial hardship, suggested that the amount due could be paid in two installments!



Electronic Walls

As was the case at Hanover, the highlight of 'Networks 91' exhibition was the Novell Wall of Computing where some 250 PCs were networked into a single network file server. The spectacular presentation included a laser show, rock music and comedians Little and Large live. However, the biggest applause was reserved for a noted industry editor who, as dry ice caused smoke to pour forth from one of the massed terminals, commented "reminds me of my home Commodore."

The other major show initiative was the formal announcement of Compaq's Joint Integration Agreement with Banyan, Microsoft, Novell and the Santa Cruez Operation to work together on PC networking configurations. The agreement covers co-development of products, technical support, the establishment of reference platforms and – a co-marketing liaison. Companies, says Novell, have to work together; it is too complicated for one company to do it all itself.

It's 'Newsier' by Satellite

The EEC are promoting plans for a multi-lingual European satellite TV news channel called 'Euronews', and promising Community funds to support the project. The plan is to start broadcasting nine hours of programmes every day in English, French, German, Italian and Spanish in September 1992, and have a round-the-clock service going by the end of 1993. Meanwhile, more down to earth news (if that is the right term for satellites) is that, despite the upheavals at Sky and BSB, the number of satellite installations is doubling annually.

With the 32-channel Astra satellite 1B now operational, already taking advantage of the additional transponder capacity, BSkyB is broadcasting a second 24-hour, pay-TV movie channel named *The Movie Channel*. The 'Sky Sports' channel will also be making use of Astra 1B, complementing Sky One, Sky News, and Sky Movies+ on Astra 1A.

Meanwhile, Maxwell Communications has linked forces with France Telecom to provide private television channels for large companies and news services. Presumably the proposed service will make use of the Marco Polo satellite channels vacated by BSB.

Picture Caption Challenge

The Challenge this month goes underground. No, its not under-performing ICL sales teams being sent to the salt mines. So what is ICL up to? Is it:

- ★ ICL rewarding its staff with indoor tennis facilities.
- ★ ICL opens a new 'safe' car park for local residents.
- ★ ICL designing a new underground airship with direct connection to 'Down Under'.
- ★ A 'fall-out' escape shelter against visiting Fijitsu executives.

Well not quite. In fact ICL has opened a test centre in a Cheshire salt mine for monitoring electromagnetic and radio emissions from equipment. The salt walls absorb radiation while there is minimal ambient radiation 200m below the earth's surface.

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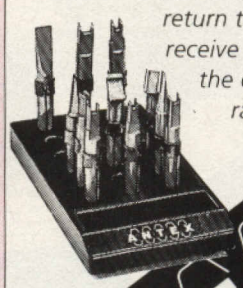

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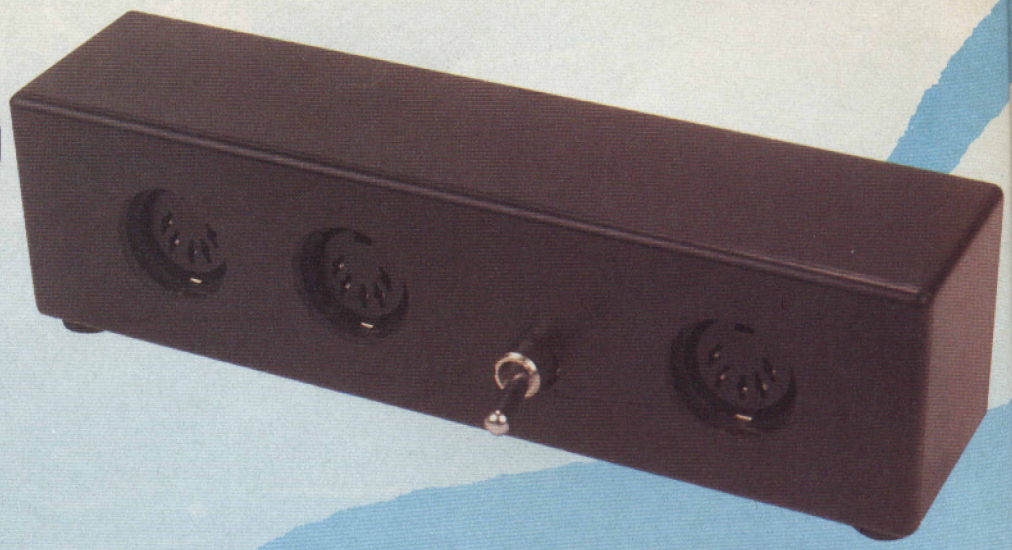


2 WAY MIDI Switch Box

by Joe Fuller

Introduction

For the uninitiated, MIDI, or to give it its full title, Musical Instrument Digital Interface, is a means of allowing electronic musical instruments, and other related hardware, to communicate by means of a common standard of information interchange. Most modern music equipment is equipped with MIDI, ranging from a £99.95 Casio synthesizer to a £1999.95 Akai Sampler, a Roland drum machine to an Alesis signal processor, and a proprietary stage lighting controller to an Atari computer. MIDI is available for most musicians to use in various guises. For a full explanation of what MIDI is, and how it works, refer to 'Electronics' March to May 1987 issue 22.

The Two-Way MIDI Switch Box is an extremely handy project for anyone who uses MIDI. The switch box is simple to build and easy to use, best of all it costs less than a tenner! Commercially these units are at least twice that price. So what does it do? It allows either: a MIDI signal to be interrupted or connected to equipment; or a MIDI signal to be routed down one of two paths to other equipment; or even to select between two sources of MIDI signal.

Circuit

Figure 1 shows the circuit diagram of the two-way MIDI switch box, if that is, it really warrants being called a circuit! With only three 5-pin DIN sockets, a double pole change-over switch and no actual electronics at all, it is simplicity itself. I won't patronise you with a circuit description as anyone with a grain of common sense should be able to see just what is going on. The advantage of the totally passive nature of the switch box is that apart from needing no power source, the unit will work 'either way round', i.e. one input and two outputs, or two inputs and one output.

Construction, Testing and Assembly

Referring to Figure 2, assemble the components onto the PCB, it is however recommended that the wire link is fitted first, otherwise it will be found to be a bit tricky to fit it in between the other components. A multimeter set to a resistance or continuity range may be used to verify switching operation. Photo 1 shows the assembled PCB.

The hardest bit comes next – drilling

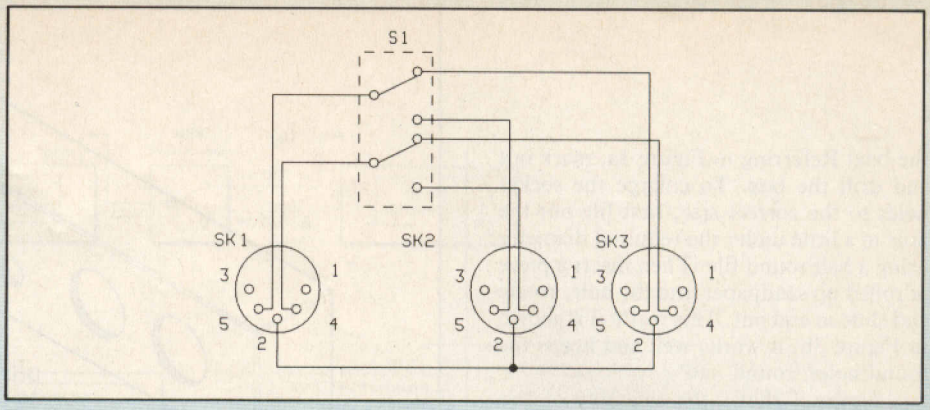


Figure 1. Circuit diagram.

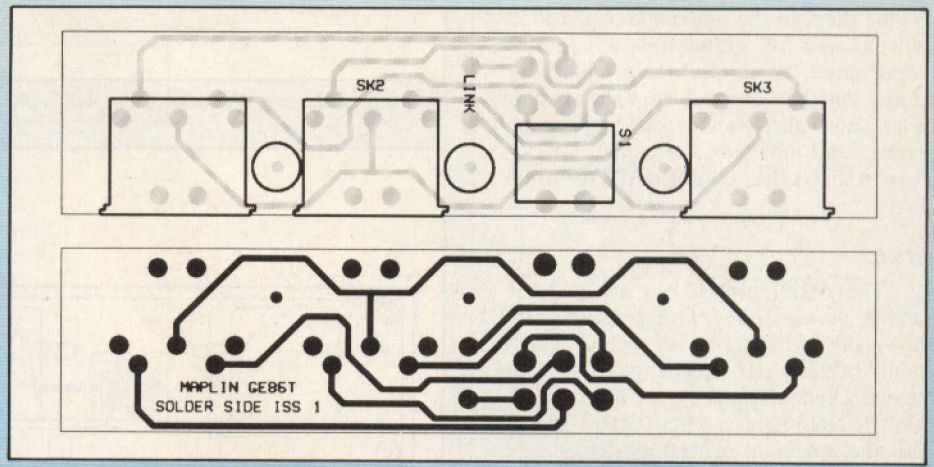


Figure 2. PCB legend and track.

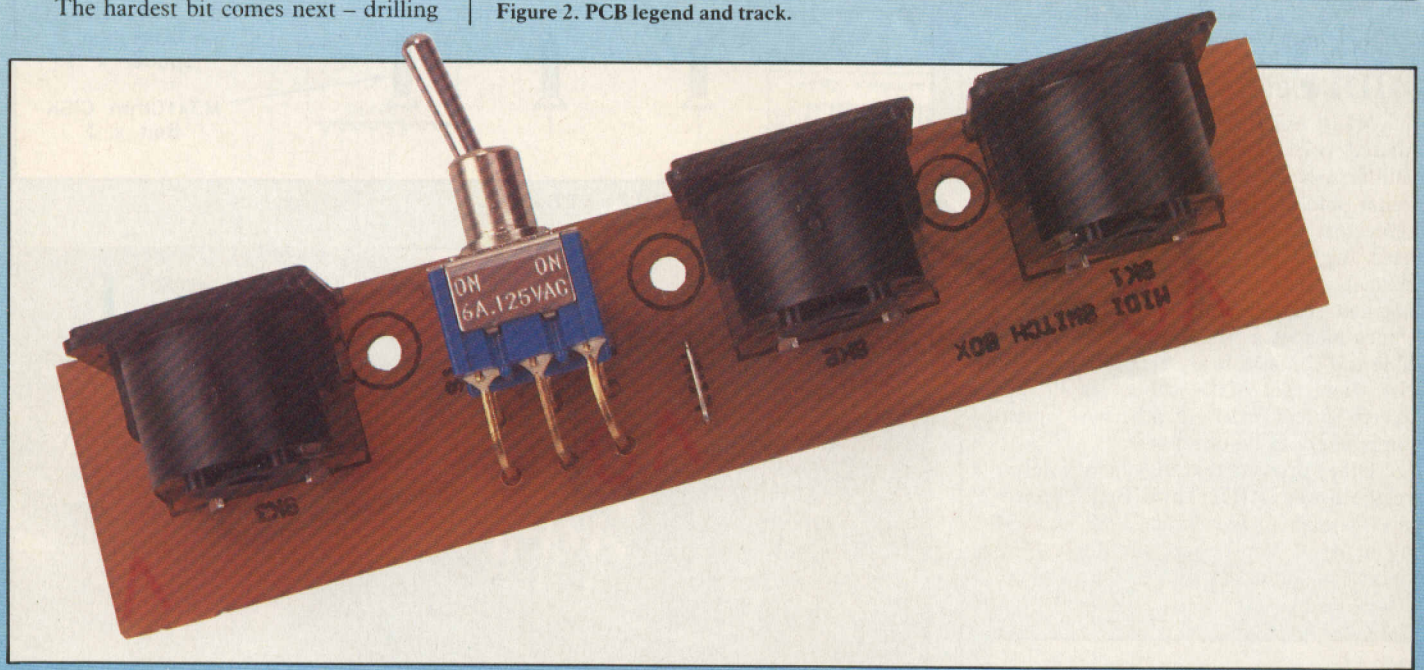


Photo 1. The assembled PCB.

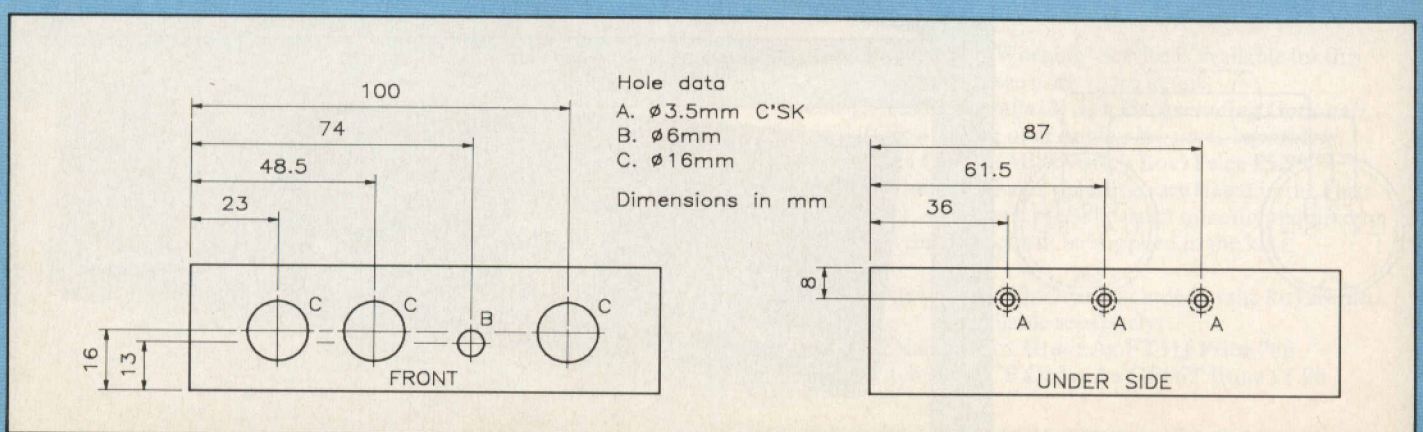


Figure 3a. Box drilling details.

the box! Referring to Figure 3a, mark out and drill the box. To enlarge the socket holes to the correct size, first file out the hole to a little under the required diameter using a half round file. Then insert a piece of rolled up sandpaper into the hole, rotate and slide in and out. This method is shown in Figure 3b; it works well and keeps the round holes 'round' too!

Figure 4 shows the assembly of the switch box, which can be a little fiddly. An easy way of positioning the M3 spacers is to glue them to the underside of the PCB with a spot of cyanoacrylate adhesive (super glue), be careful not to glue your fingers together! Photo 2 shows how a pair of long nose pliers can be used to place the washers and nuts onto the bolts.
Photo 3 shows the assembled MIDI Switch Box.

Use

The MIDI switch box has a wide variety of uses, a few suggestions are shown in Figures 5a to 5e, each of which should be fairly self explanatory. The front panel sockets and switch are arranged so that the 'common' is the left-most socket and the position of the switch toggle indicates from/to which socket the MIDI signal is routed to/routed from.

MIDI Leads

MIDI leads are sold commercially at inflated prices compared to their audio counterparts, simply because 'MIDI is digital and requires special cable and connectors' – not true! MIDI leads may be made up quickly and cheaply using 'normal' good quality connectors and screened cable. Figure 6 shows the connections of a MIDI cable. Suggested cable and connectors are given in the Parts List. Note that MIDI cables should not exceed 50 feet in length otherwise operation is likely to be unreliable.

Other projects that may be of interest are the 8-way MIDI Thru' Box 'Electronics' October to November 1989 issue 34 and a MIDI lead tester, see Bob's Mini Circuits in the next issue of 'Electronics'.

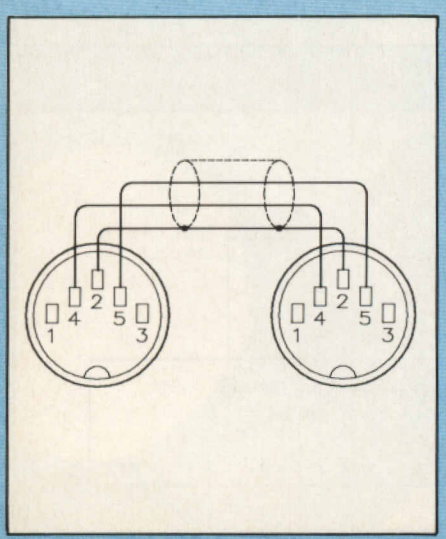


Figure 6. MIDI lead connections.

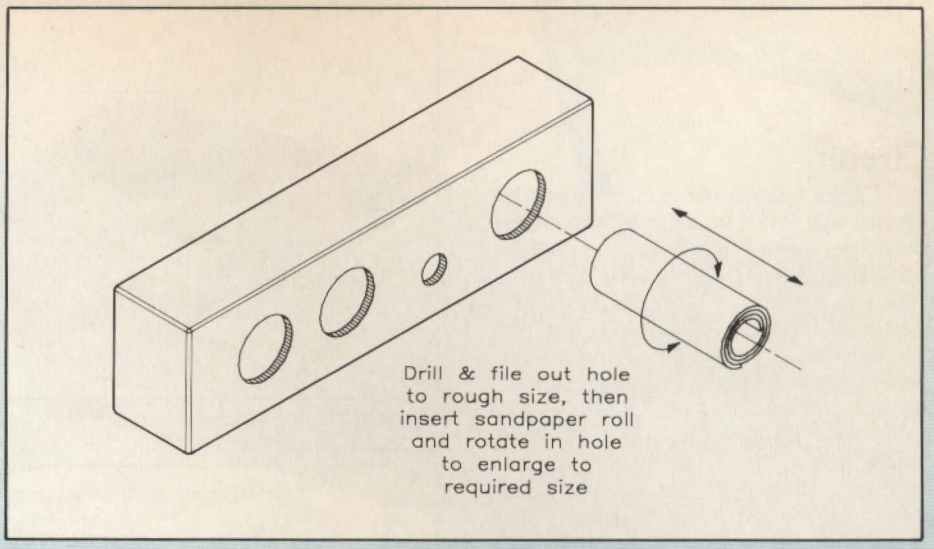


Figure 3b. Enlarging the socket holes with a piece of rolled up sandpaper.

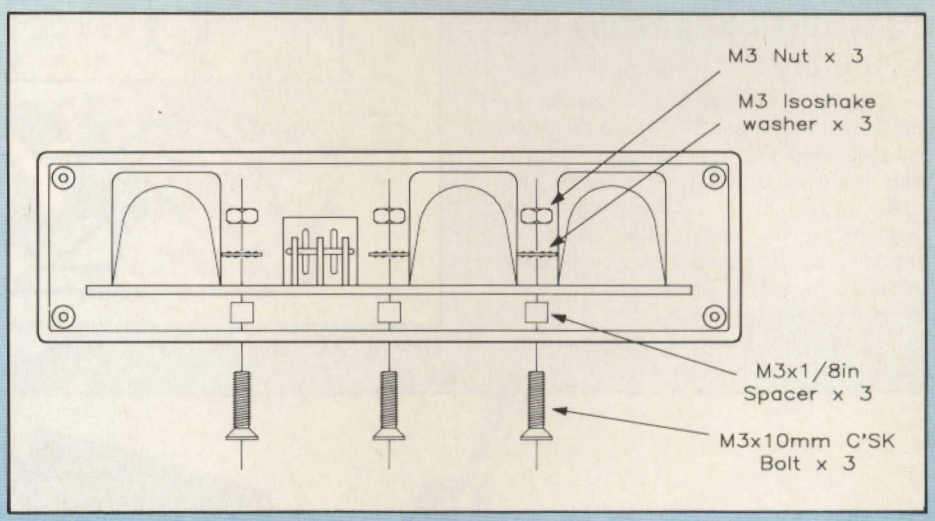


Figure 4. Assembly of the MIDI Switch Box.

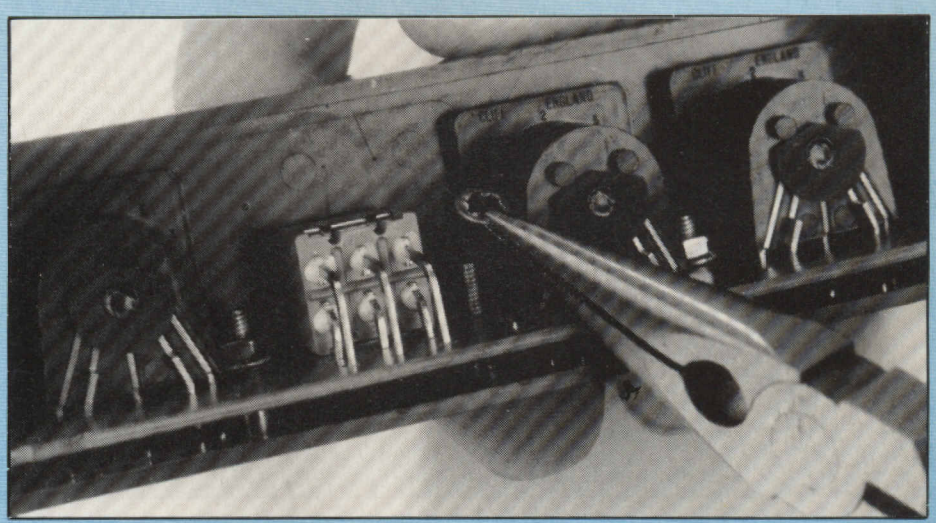


Photo 2. Using a pair of long nose pliers to place the M3 hardware.

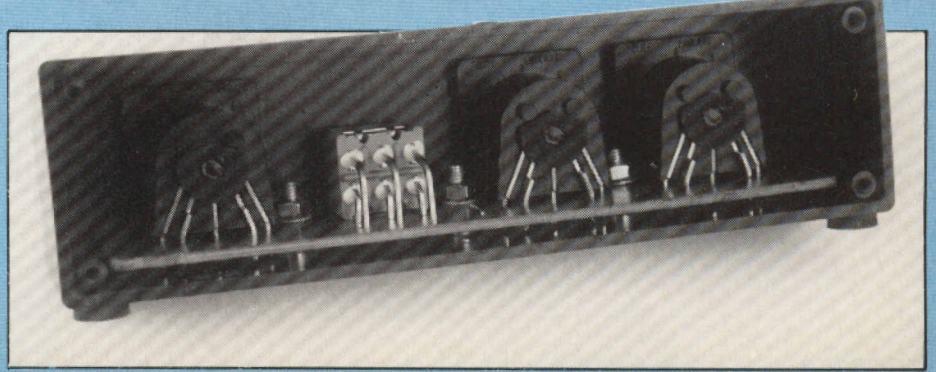


Photo 3. The assembled Two-Way MIDI Switch Box.

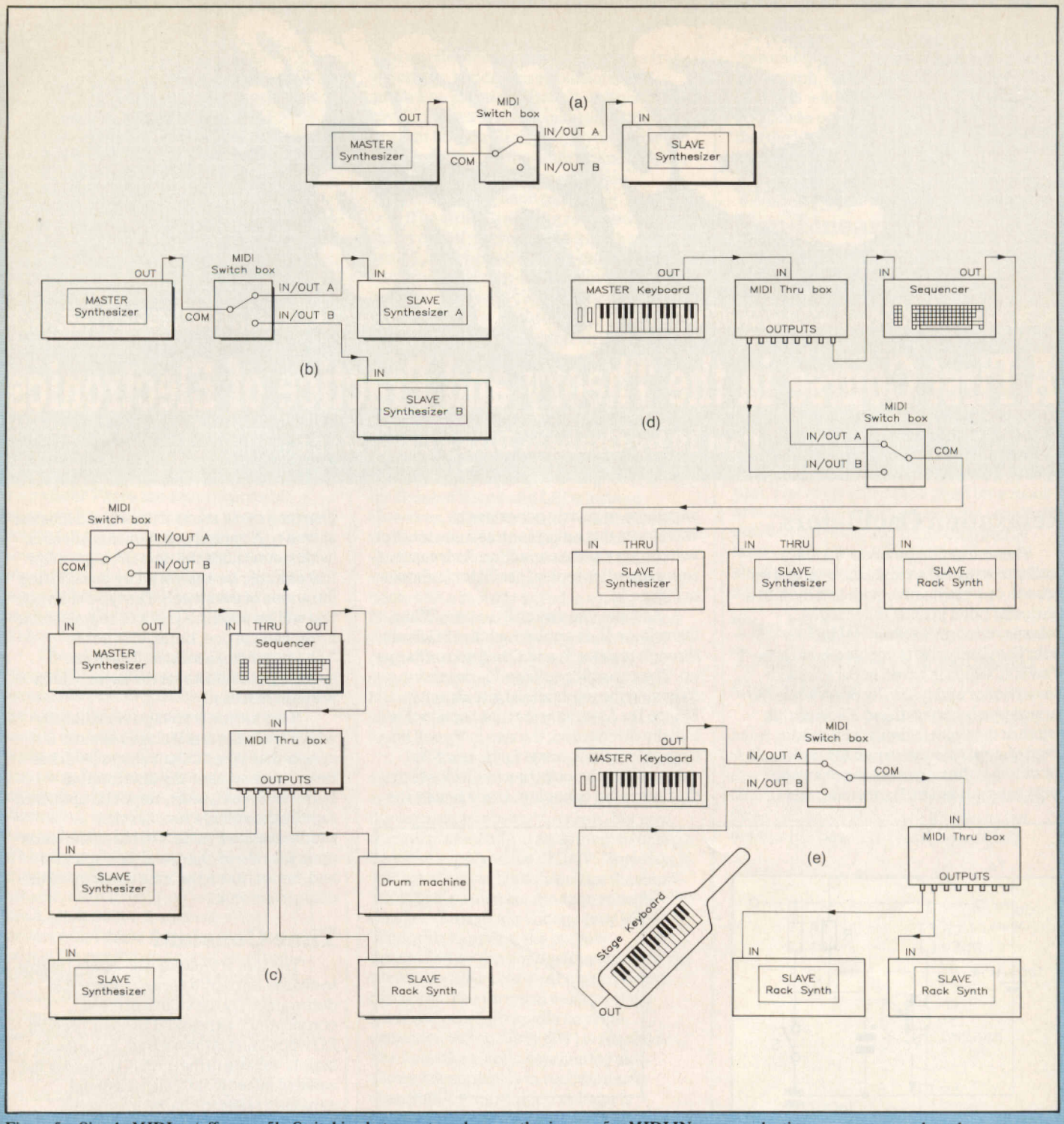


Figure 5a. Simple MIDI on/off use. 5b. Switching between two slave synthesizers. 5c. MIDI IN source selection on a sequencer based system. 5d. Switching between master keyboard or sequencer to drive slave synthesizers. 5e. Switching between master keyboard or stage keyboard to drive slave synthesizers.

TWO-WAY MIDI SWITCH BOX PARTS LIST

MISCELLANEOUS

R/A Toggle DPDT Lft/Rt	1	(FA73Q)
PC DIN Socket 5-Pin A	3	(YX91Y)
Small Narrow Box	1	(FT31J)
Pozi Screw M3 × 10mm	1 Pkt	(LR57M)
Isoshake M3	1 Pkt	(BF44X)
M3 Spacer ⅛in	1 Pkt	(FG32K)
Small Stick on Feet	1 Pkt	(FE32K)
MIDI Switch Box PCB	1	(GE86T)
Leaflet	1	(XT07H)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)

Din Plug 5-Pin A	As Req	(HH27E)
Fleximic Black	As Req	(XR98G)

The Maplin 'Get-You-Working' Service is available for this project, see page 15 for details.

The above items are available as a kit (excluding Optional), which offers a saving over buying the parts separately.

Order As LP75S (Midi Switch Box) Price £5.95

Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately.

Small Narrow Box **Order As FT31J Price 78p**

Midi Switch Box PCB **Order As GE86T Price £1.98**

Square One

A First Course in the Theory and Practice of Electronics

Part 10 by Graham Dixey C.Eng., M.I.E.E.

Relaxation Oscillators

The above title belongs to a class of oscillator in which a capacitor charges up through one conductive path and then, at a particular point in time, discharges (relaxes) through another conductive path. The discharge is initiated by a form of switch, which is wired in parallel with the capacitor and normally open while the capacitor is being charged. Closing this switch at the point in time mentioned above discharges the capacitor rapidly. If the switch is then opened, the charging cycle can start again. Performing this sequence regularly generates a waveform, this being seen as a sawtooth of voltage across the capacitor. A circuit that represents this type of oscillator is shown in Figure 1a.

Assume that switch S is open. When the voltage V_S is applied, a current I flows through resistor R, and C begins to charge up. The capacitor voltage V_C rises, following the exponential law shown in Figure 1b. Assuming that the capacitor is initially discharged, the rise in V_C will be from zero volts to some finite, positive value, at which point the switch closes to discharge the capacitor. In the figure, the charging cycle starts at time t_0 and finishes at time t_1. A natural question that arises is, 'what determines the time t_1?', a question that can only be answered by considering the action of the switch. The type of switch that will be used in a practical circuit is not a mechanical one, but an electronic 'voltage sensitive switch'. There are several possibilities for the latter, which we shall discuss.

If the switch is voltage sensitive, by which we mean that it closes when it senses that a particular voltage level has been reached, then the time interval between times t_0 and t_1 depends upon how rapidly the voltage reaches this predetermined value. This itself depends upon the rate of charge of the capacitor and, hence, upon the 'time constant' of the charging circuit.

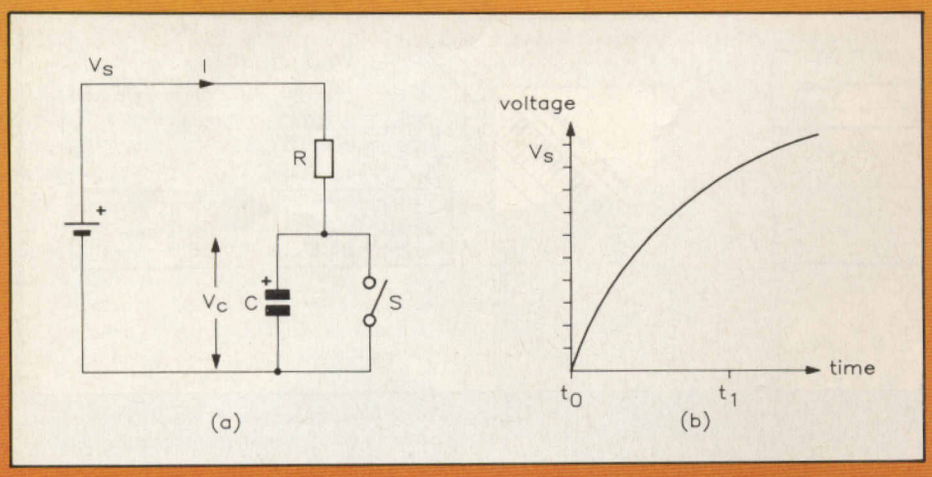


Figure 1. (a) Simple relaxation circuit, (b) the exponential curve of voltage/time for the capacitor.

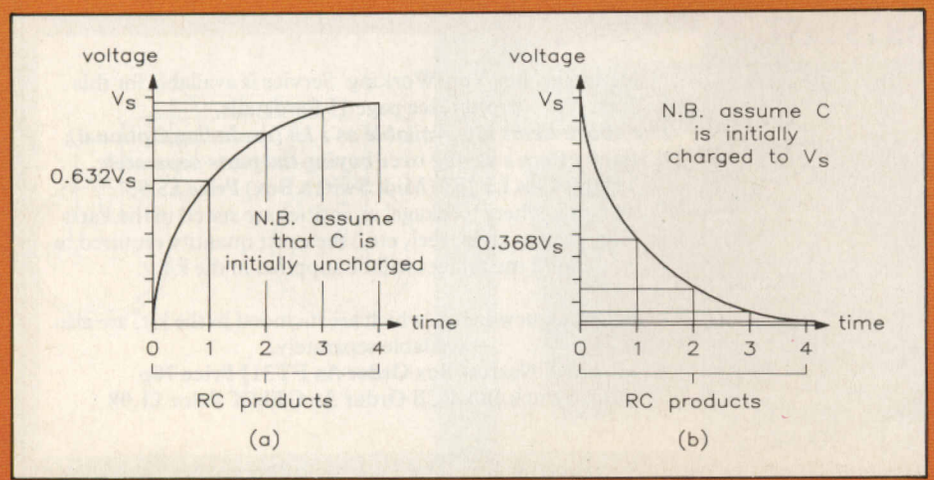


Figure 2. (a) Exponential charging curve and (b) exponential discharge curve for a capacitor.

Time Constant

The rate at which a capacitor C is able to charge through a series resistor R is determined by the values of these components, expressed by their product RC whose unit is the second. For a given supply voltage to the circuit, the larger the value of either R or C, the longer the capacitor takes to charge up to some specified voltage. As mentioned earlier, the shape of the charging curve is 'exponential' and such a curve is shown in more detail in Figure 2(a). This figure shows the real meaning of the product RC (known by the Greek letter 'τ', its value being marked along the base line several times. Projecting the first of these up to meet the curve, it intercepts at a voltage level that is approximately equal to 63·2% of the supply voltage V_S. The end of the next interval ($2 \times \tau$) intercepts the curve at a point that is 63·2% 'of the remaining difference ($V_S - V_{C1}$)', and the same is true for each interval that follows. From this we can see that each successive time interval brings the capacitor voltage closer and closer to the value of the supply voltage V_S, but that it never actually equals it, except after infinite time has elapsed! However, this is a somewhat academic point and it is usually considered that, after four such intervals, the capacitor and supply voltages are virtually equal.

Taking an example, if a 10μF capacitor is being charged through a 10k resistor from a 10V DC power supply, the time constant will be

$R \times C = 10^4 \times 10^{-5} = 0{\cdot}1s$
(R in ohms and C in farads)

and after 0·1s, the capacitor voltage will be 0·632 x 10 = 6·32V while, after 0·4s, the capacitor voltage will be almost equal to 10V (actually 9·98V to two decimal places).

Figure 2(b) shows the exponential curve for a capacitor that is discharging. This behaves in a similar manner, the capacitor voltage 'decreasing' by 63·2% (i.e. to 36·8%) in each interval in this case. After four intervals, each of τ seconds, the capacitor voltage is virtually zero.

A Suitable Switch

The question is, what shall we use for the switch? There are several possible answers. For the first one, let us go back a little in time to a device not so widely used nowadays, the neon indicator. The way in which this is able to produce an oscillatory output is fundamental to all relaxation oscillators. The circuit for a neon oscillator is shown in Figure 3(a).

The neon indicator itself, shown in Figure 3(b), is a device of simple form. It comprises a small glass bulb within which are a pair of metal electrodes. Prior to sealing the bulb, the air is pumped out and replaced by a small quantity of the inert gas, neon. In use a voltage is applied across the electrodes, either direct or alternating, in order to cause a current to flow in the gap between the electrodes. When this voltage is low, i.e. less than a critical level known as the 'striking voltage', the current flow is extremely small, almost zero. It consists of the movement of those free electrons that exist in the gas due to normal ambient temperature, under the influence of the electric field created by the applied voltage. As this voltage is increased, the electrons are accelerated faster and faster and collisions occur between them and the slowly moving gas atoms. These collisions detach further electrons from the atoms, the latter then becoming what are known as 'ions', hence the phenomenon is known as 'ionisation'. Since there are now more electrons in transit, there will be even more collisions. More collisions generate even more free electrons, hence more collisions still, more free electrons and so on. This effect gives rise to a massive increase in the current flow through the gas, the large number of ions of the latter giving rise to a glow with the pinkish-orange hue characteristic of neon gas.

The striking voltage required is of the order of 90V, and once the neon has struck, the applied voltage must then be reduced to a lower value, known as 'extinction voltage', in order to extinguish the neon. This is about 60-70V. To limit the current to a safe value after striking, a high value resistor must be inserted in series with the neon device. When the neon is used as a mains supply indicator, as it once commonly was, a typical value of resistor would be 1 Megohm.

This device is little used today as a panel indicator, this role being taken over by filament lamps and LEDs instead. However, it lives on as the visual element in the 'neon mains testing screwdriver'. Unscrew the cap of one of these useful tools, and inside will be found a miniature neon with a resistor wired in series with it. So small is the current drawn by the neon (less than 1mA) that the operator forms part of the conducting path without experiencing even the slightest tingle. Now, after that brief diversion, back to the circuit of Figure 3(a) for the neon oscillator itself.

A DC supply of 150V is connected to a series RC circuit, with the neon connected in parallel with the capacitor. At switch-on the capacitor voltage V_C is zero but now rises exponentially in an attempt to charge up to the supply value of 150V. However, it will not achieve this value since the neon will strike when the capacitor voltage reaches the striking voltage (say 90V). When this happens, the current demanded by the conducting neon will be drawn from the charge acquired by the capacitor. The terminal voltage of the latter will now fall rapidly until the extinction voltage (say 60V) is reached. The neon then stops conducting and allows the capacitor to recommence charging. As the striking voltage is reached again the cycle repeats, which it will continue to do as long as power is applied to the circuit.

The result is a sawtooth waveform, which appears at the junction of R and C. Assuming the voltages quoted in the last paragraph, this will oscillate between the values of +60V and +90V, that is with an amplitude of 30V, see Figure 3(c). Notice that the level never reaches zero because the capacitor never fully discharges.

The Sawtooth Wave – Non-Linearity

Because the charging curve is exponential, the sawtooth waveform is somewhat non-linear. This rather restrained statement can embrace all situations from 'slightly' non-linear to 'extremely' so! The linearity of the sawtooth wave improves quite noticeably when the supply voltage value is well above that of the neon's striking voltage. This is because the charging is restricted to the lower part of the exponential graph, which is much more linear that the upper part. The price paid is the need for a much greater supply voltage. Since the residual non-linearity may still be unacceptably large, other ways of improving linearity should be looked at. We shall return to this subject shortly.

The Unijunction Transistor – A Practical Oscillator

A relaxation oscillator, following the basic principles discussed, can be realised using a low voltage supply and a modern semiconductor device, the unijunction transistor (UJT). The latter has three terminals which are known as the emitter (e), base 1 (b1) and base 2 (b2).

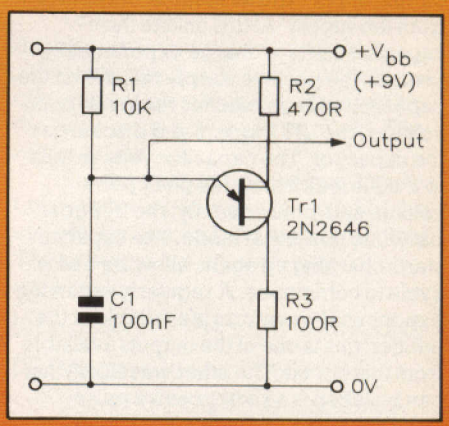


Figure 4. The unijunction oscillator.

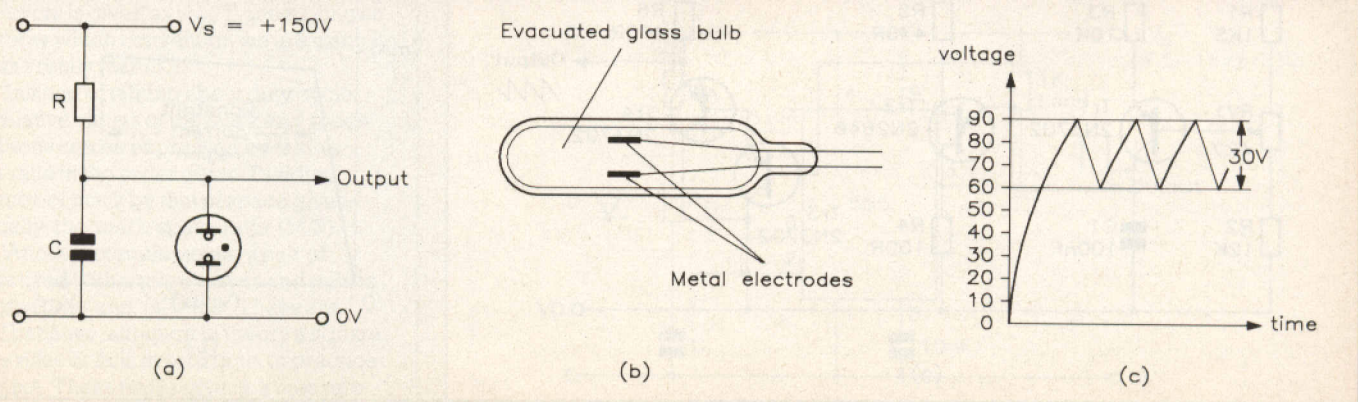


Figure 3. The neon relaxation oscillator (a) circuit (b) the neon itself and (c) the sawtooth output waveform.

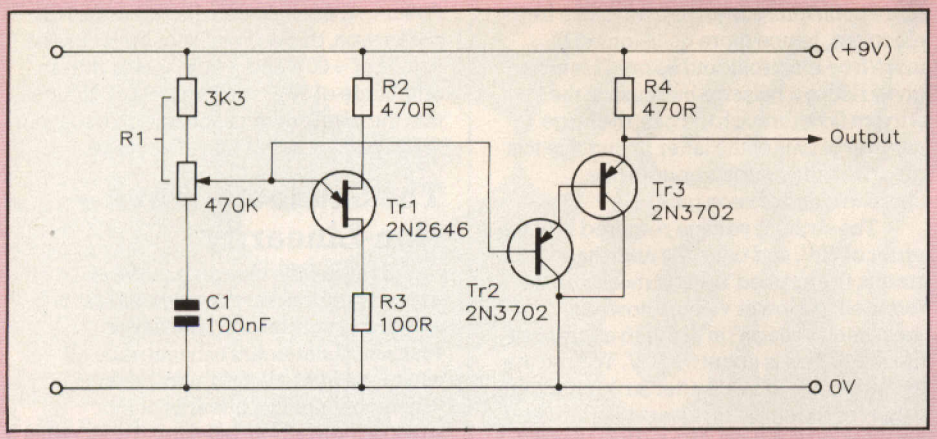


Figure 5. The circuit of Figure 4 with variable frequency and buffered output.

A circuit using this device as a means of discharging a capacitor is shown in Figure 4. The emitter is connected to the junction of R1 and C1, and a resistor is connected in series with each of the base leads.

In use a small current, a milliamp or two typically, flows through a series circuit comprising the two resistors and the path between the base terminals. This establishes a voltage gradient within the semiconductor such that a particular voltage level, known as the 'peak point voltage' must be applied to the emitter terminal before the UJT 'triggers'. When it does, the resistance of the path between the emitter and base 1 drops to a very low value. It is this low resistance that is used to discharge the capacitor. The facts just stated provide enough clues for the operation to be deduced. Let us assemble them in the right order.

When the power is applied to the circuit, the UJT draws some steady current from the supply. At this instant the capacitor starts to charge exponentially towards the positive supply rail. When the capacitor voltage reaches the 'peak point voltage', the UJT triggers and discharges the capacitor. The capacitor voltage falls to a value well below the peak point voltage and, consequently, the UJT goes back into its normal mode. The capacitor starts charging up again, allowing a new cycle to commence. A regularly recurring exponential waveform is available at the emitter; this is one of the outputs available from this circuit. The other waveform that can be taken is a short positive pulse which appears at the base 1 terminal during the time that the capacitor is discharging. It is, of course, due to the flow of the large discharge current through R3 to 0V at this time. While it is not particularly relevant to the present discussion, it is still worth a mention. This positive pulse is often used to trigger thyristor devices.

The circuit of Figure 4 can be modified to improve its performance and versatility. By making R1 variable, the time constant for charging the capacitor is then variable. This means that the frequency of operation can be controlled. By using a fairly large value potentiometer, quite a wide frequency range can be obtained, in this case from about 25Hz to rather more than 3kHz. If the value of C1 is also arranged to be switched, several consecutive ranges can be obtained, giving very wide frequency coverage. At the same time, a compound emitter follower (TR2/3) is included so that the output is available at low impedance to allow it to drive other circuits. This modified circuit is shown in Figure 5.

Figure 6 shows a method of linearising the sawtooth. This problem of the exponential charging of the capacitor was mentioned earlier. Now we can see a solution.

Refer back now to the circuit of Figure 1. The problem actually arises because, in this circuit, the capacitor is being charged from a constant voltage source (the supply voltage V_S). What this means is that when the capacitor voltage is zero, at the start of the charging cycle, the current flowing into the capacitor is large; it is equal to V_S/R by Ohm's law. However, as the capacitor voltage rises with time, the charging current progressively falls, being given at any instant by the expression $(V_S - V_C)/R$, also by Ohm's law. The closer that the capacitor voltage approaches the supply voltage the smaller is the voltage across the resitor R and, consequently, the smaller is the charging current. This charging current is, itself, following an exponential law, one in which the value is decreasing with time. If, in some way, we can maintain a constant charging current into the capacitor for the whole of the charging cycle, the capacitor voltage will rise in a linear manner rather than an exponential one. This is what the circuit of Figure 6(a) does.

The explanation can be followed by reference to the graph of Figure 6(b). This graph relates the collector current of a bipolar transistor (I_C) to the voltage between collector and emitter (V_{CE}). This is termed an 'output characteristic' and it is usual to draw a 'family' of these, each curve in this family being for a particular value of base current I_B. For the present purposes, it is not necessary to draw more than one in order to establish the principle that we are employing; its shape tells us all we need to know. It can be seen that it consists, more or less, of two straight line sections. The first, which rises very steeply, is the region normally avoided in use, the second section is of great interest. This latter is almost horizontal and thus implies the following statement:

'Over a very wide range of collector-emitter voltage, the current flowing in the collector circuit is virtually constant'.

For this reason the bipolar transistor is sometimes referred to as a 'constant current device'. We can make use of this property if we arrange for the collector current of the transistor to charge the capacitor. Now look at Figure 6(a).

A PNP transistor (TR1) is provided with a base bias (which may be adjusted by RV1) and the capacitor C1 is included in series with the collector circuit of this transistor. To complete the charging circuit a 10k resistor is wired into the emitter lead. According to the setting of RV1, a particular collector current flows.

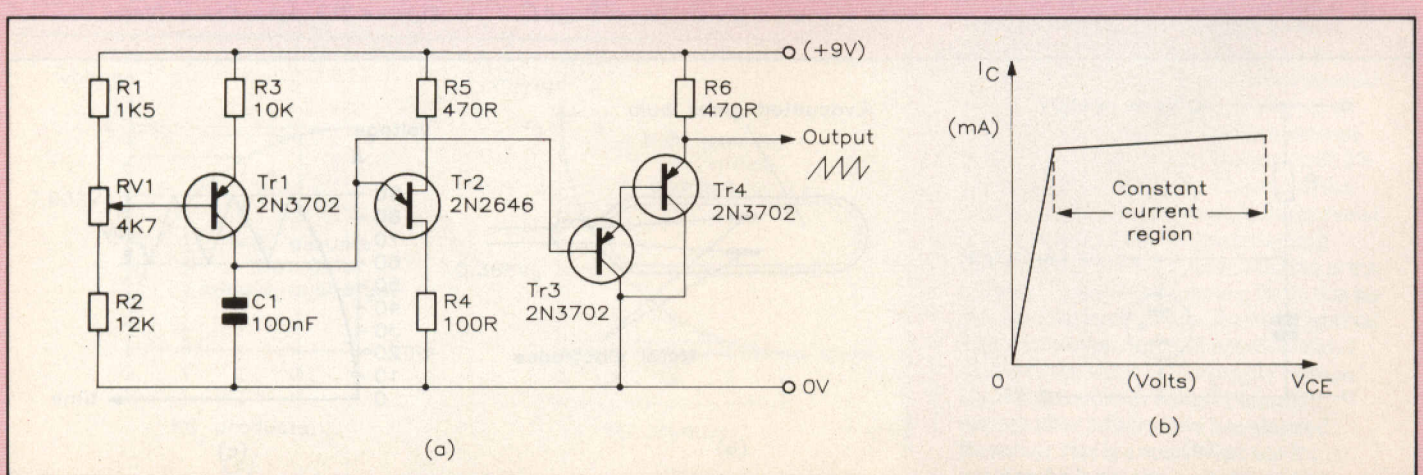


Figure 6. (a) The UJT oscillator with 'linearised' sawtooth output using a constant current charging circuit, (b) output characteristic of BJT showing 'constant current' region.

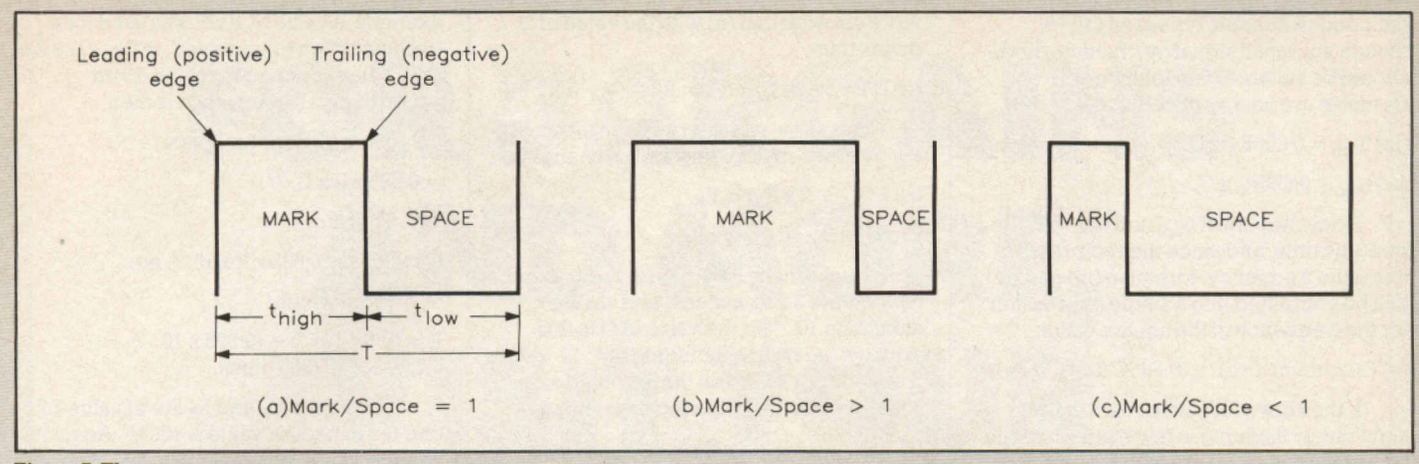


Figure 7. The square wave.

This constant current charges the capacitor C1, the voltage across this capacitor being used in the usual way to trigger the UJT. Variation of RV1 controls the collector current which, in turn, controls the rate of charge of C1 and, hence, the frequency. The output waveform at the emitter of the UJT, now nicely linear, is buffered in the same manner as in the previous circuit.

Square-Wave Generators

Figure 7 shows three waveforms that are often referred to as square waves. Strictly speaking, a waveform is only square when the *mark* (the period during which the wave is 'high') and the *space* during which the wave is 'low') are equal. Otherwise, the wave is rectangular and in an extreme case might just be referred to as a pulse waveform. However, for simplicity, we shall refer to the outputs of the circuits shortly to be described as 'square', whatever the relation between the mark and space durations. Simple as it is, the square wave gives rise to its own terminology, which is included in Figure 7.

The points at which level transitions take place are termed 'edges'. The edge at which the level changes from low to high is termed the 'leading edge' or 'positive edge'; the other, where the transition is from high to low, is known as the 'trailing edge' or 'negative edge'.

The duration of the complete wave, mark and space, is termed the periodic time (T) and the reciprocal of this (1/T) gives the frequency of the square wave. The ratio of the duration of the space (t_{low}) to the total period T (i.e. (t_{low}/T) gives the 'duty cycle' (D). (N.B. in some texts the duty cycle is given as t_{high}/T, but as long as we know which convention we are using it doesn't really matter.)

Instead of talking about duty cycle, the relative values of the mark and space durations can be expressed by taking their ratio in the order given. Dividing duration of mark by that of space gives, logically, the 'mark/space ratio' (M/S).

Another complementary pair of terms used with square waves and pulses are 'rise time' and 'fall time'. These are used because, although in theory a square wave rises or falls in zero time, in practice it cannot. These terms give us a measure of the actual rate of rise and fall of the waveform. They are defined as the time

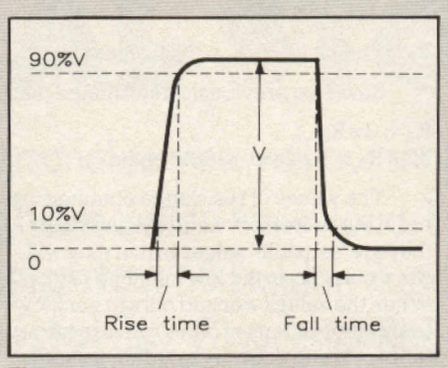


Figure 8. Rise and fall times of a square wave.

between the points 10% of full amplitude, and 90% of full amplitude. They are illustrated in Figure 8, from which it should be noted that the edges of the wave are actually steep exponentials. This means that somewhere there is an RC product that we can blame for this imperfection in the waveform!

There are a number of possible ways of generating a square wave. We shall start by looking at a circuit that we met earlier on in the series, one that uses the versatile 555 IC. This latter is often referred to as a 'timer' IC, since it is capable of generating time delays for various purposes. It is capable of generating square waves using either of two possible modes, known as 'astable' and 'monostable' modes. Here we shall just consider the former mode. The circuit for the astable 555 circuit is shown in Figure 9. The term 'astable' means that the circuit has no stable state in which it can rest, in other words it oscillates continuously, changing alternately from one state to the other.

The components external to the IC itself are minimal in number. An RC circuit consisting of R_A and R_B in series with C provides the time constant as in the other relaxation oscillators previously discussed. In this case the capacitor C charges up towards the supply voltage (during which the output at pin 3 is high) until the potential at pins 2 and 6 (strapped together) reaches a value at which an internal switching action occurs; the capacitor then discharges and the output (pin 3) changes state from high to low. The cycle then repeats once C has discharged. The only variables that we need bother about in this circuit are the values of R_A, R_B and C. The load resistor, pin 3 to +5V, may be taken as 1k, while the capacitor from pin 5 to ground typically has a value of 10nF.

One point to note about this circuit is that one other component, a diode, is shown in chain line. This is because it offers an option, which is determined by the value of the duty cycle required. The rule is as follows:

For duty cycles that are less than 50% (corresponding to mark/space ratios that are greater than 1:1), the diode is omitted. The following formulae are then applicable:

(i) Frequency $f = 1{\cdot}44 \div ((R_A + 2 \times R_B) \times C)$.

(ii) Duty cycle $D = R_B \div (R_A + 2 \times R_B)$.

For duty cycles equal to or greater than 50% (corresponding to mark/space ratios of 1:1 or less), the diode should be

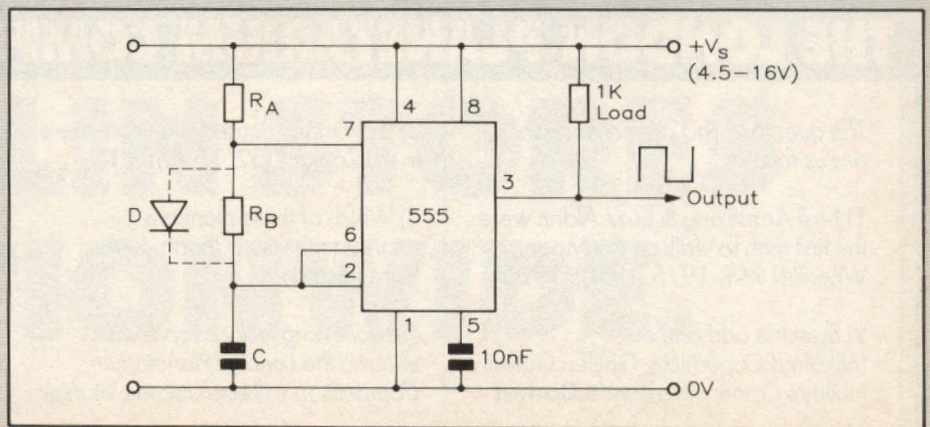


Figure 9. The 555 astable oscillator circuit.

included. A suitable type is an OA79, though any small signal *germanium* diode should be suitable. The following formulae are now applicable:

(iii) $t_{high} = 0{\cdot}695 R_A \times C$.

(iv) $t_{low} = 0{\cdot}695 R_B \times C$.

Since the sum of t_{high} and $t_{low} = T$, the periodic time, and since the reciprocal of this is the frequency, formulae (iii) and (iv) can be combined into a single expression for the frequency of the square wave:

(v) Frequency $f = 1 \div (0{\cdot}695C \times (R_A + R_B))$.

If the above formulae seem at first sight rather daunting, a few examples will show how easy they are to use in practice. When some confidence has been gained in using them, it becomes possible to design a square wave generator with any required frequency and mark/space ratio. To show the procedure, three examples will be taken, using the formulae as appropriate.

Example 1

In this example we shall assume that we need a frequency of 100Hz with a M/S ratio of 4:1; this latter corresponds to a duty cycle D of only 20% (0·2 as a decimal fraction). We therefore need to use equations (i) and (ii), repeated here.

(i) Frequency $f = 1{\cdot}44 \div ((R_A + 2 \times R_B) \times C)$.

(ii) Duty cycle $D = R_B \div (R_A + 2 \times R_B)$.

What will be evident from an inspection of these equations is that they contain *three* unknowns, two resistors and a capacitor. Since the solution in such a case would normally involve having three simultaneous equations, this seems to pose a bit of a problem. But there is a simple way round it; we turn one of the unknowns into a known, by a simple bit of guesswork, and the one we choose for this treatment is the capacitor C. We start by estimating a likely and convenient value. This is not sheer guesswork; after a while we get a feel for the sort of value that we can use. All that matters is that the resistor values that we then calculate are sensible values. If not, we re-estimate C and try again. Here goes then.

Let us start by assuming that $C = 1\mu F$ (10^{-6} farads). This we can substitute into equation (i) but, before doing so let us write out equation (ii) with the value of D given, thus

(ii) Duty cycle $D = 0{\cdot}2 = R_B \div (R_A + 2 \times R_B)$.

This allows us to write R_A in terms of R_B, by cross-multiplying and rearranging:

$0{\cdot}2 \times (R_A + 2 \times R_B) = R_B$.

From which: $R_A = 3 \times R_B$.

Thus, where R_A appears in equation (i) we write $3 \times R_B$ instead, and we also substitute 10^{-6} for the value of C in this equation as well as including the frequency of 100Hz on the left-hand side. This gives us the following expression:

(i) $100 = 1{\cdot}44 \div ((3 \times R_B + 2 \times R_B) \times 10^{-6})$.

This rearranges to give

$5 \times R_B = 1{\cdot}44 \times 10^4$,
$R_B = (1{\cdot}44 \times 10^4) \div 5, = 2880$ ohms.

Since we previously determined that

$R_A = 3 \times R_B$,
then $R_A = 3 \times 2880, = 8640$ ohms.

The values of resistance obtained are not in the preferred range of values but they are 'sensible' values in that they will draw currents in the low milliamp region. When the values worked out are very low (only ohms or tens of ohms) or very large (approaching or in the megohm region), new values should be calculated for revised estimates of the value of C. If the resistor values calculated are too small, choose a small value of C and vice-versa.

Example 2

In this case, we assume that we want a true square-wave output, that is one with a 1:1 M/S ratio. Let the required frequency be 1000Hz. Because a 1:1 M/S ratio corresponds to a duty cycle of 50%, the equations to use are (iii) and (iv) and the diode should be included. The design procedure is as follows.

For the frequency stated of 1000Hz, the periodic time is 1/1000 = 1ms. Since the M/S ratio is 1:1, the high and low times are equal (each equal to 0·5ms) and the values of R_A and R_B are equal. Thus, either equation (iii) or (iv) can be used, the value of resistor being the same in both cases (which we shall just call R). Start off by assuming that C = 100nF (10^{-7} farads). This should give a sensible resistor value because, whereas in the previous example, a value of $10\mu F$ was used for a frequency 'ten times lower', in this case we can scale the capacitor value down accordingly. The equation is then

Time of mark (or space)

$= 0{\cdot}695 \times R \times C$,

Therefore,

$0{\cdot}5 \times 10^{-3} = 0{\cdot}695 \times R \times 10^{-7}$, etc.

From which

$R = (0{\cdot}5 \times 10^{-3}) \div (0{\cdot}695 \times 10^{-7}), =$
$0{\cdot}72 \times 10^4 = 7200$ ohms.

Thus, both R_A and R_B are of value 7·2k and the capacitor value is 100nF. Again the resistor value is of a sensible size, if not an actual preferred value. If the frequency of 1000Hz is critical, this value will have to be obtained by a combination such as a 6·8k fixed resistor in series with a 1k preset.

Example 3

As a final example assume that we wish to generate a short pulse at regular intervals, say a $100\mu s$ pulse every 1ms. The length of the mark will be $100\mu s$ (10^{-4}s) while that of the space will be $900\mu s$ (9×10^{-4}s). Because the duty cycle is greater than 50%, we shall again use equations (iii) and (iv) and include the diode. Writing these equations, and assuming that C is a 100nF capacitor, we have:

(iii) $t_{high} = 10^{-4} = 0{\cdot}695 \times R_A \times 10^{-7}$.

(iv) $t_{low} = 9 \times 10^{-4} = 0{\cdot}695 \times R_B \times 10^{-7}$.

From equation

(iii) $R_A = 10^{-4} \div (0{\cdot}695 \times 10^{-7})$,
$= 1439$ ohms

and from equation

(iv) $R_B = (9 \times 10^{-4}) \div (0{\cdot}695 \times 10^{-7})$,
$= 12950$ ohms.

In fact, having worked out one resistor value, the second follows readily by noting that they are each directly proportional to the length of the relevant time period i.e. R_A/R_B = mark/space.

There are many other circuits for generating sawtooth waves, square waves and pulses but those given here will suffice for now. Plenty of scope there for experimentation if the idea appeals - we continue along the same lines with more circuits in the next issue.

THE LONDON PLANETARIUM COMPETITION WINNERS

The questions and correct answers are as follows:

1) Neil Armstrong & Buzz Aldrin were the first men to walk on the Moon. When? (1969, 1975, 1950): **1969**

2) Spot the odd one out. (Nikolaus Copernicus, Galileo Galilei, Halley's Comet): **Halley's Comet**

3) How many constellations are there in the Zodiac? (52, 12, 365): **12**

4) Which of these planets is nearest to the Sun? (Earth, Jupiter, Pluto): **Earth**

The following lucky people who entered the London Planetarium Competition will each receive as their prize a family ticket, admitting 2 adults and 2 children; plus a guide book:

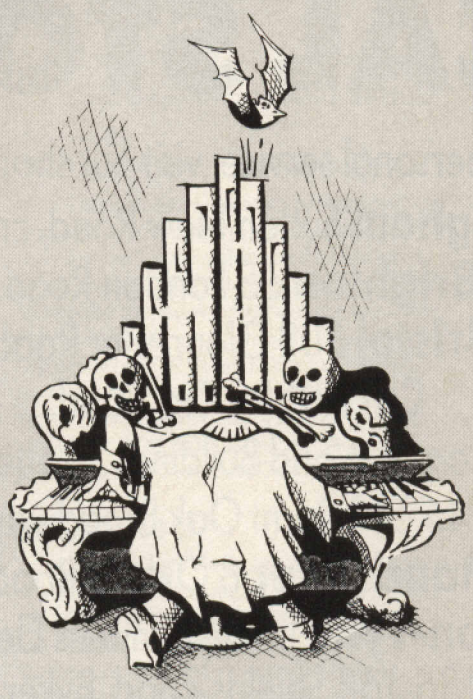
F. Read, Hayes, Middlesex; M. Barton, Milton Keynes, Buckinghamshire; A. Northcote, Loughborough, Leicestershire; C. Roberts, Huntingdon, Cambridgeshire; P. Pardue, Twyford, Berkshire; J. Michalski, New Malden, Surrey.

Stray Signals

by Point Contact

It is said that spring is a good time for falling in love, or selling a second-hand car – autumn for buying one. But for some things, there is never a good time; like buying a personal computer. If you wait six months or a year, for the same money you will get one with more memory, or twice the clock speed, or a higher resolution monitor: perhaps all of these. This is symptomatic of the never-ending advance of the electronics 'state-of-the-art' which benefits us all. In fact it is well nigh impossible for even a full-time practising professional engineer to keep up with all the latest developments. For example, only a month or two back I came across an article on an improved version of the camel transistor (Electronic Letters, 14th Feb. 1991, Vol 27 No 4). Now you might think that a camel transistor is a transistor designed by a committee, but actually it is a hot electron device realised by two camel diodes put back to back. How's that for a non-explanation; if you want further details please consult the article mentioned.

Earlier this year I paid my annual subscription to the EOCS, the Electronic Organ Constructors' Society. The desire to build an electronic organ is like a disease. In my case it is not an acute infection, but it is chronic, flaring up from time to time like malaria. Nevertheless, Point Contact has so far always managed to put off starting constructing in earnest, even though an interest was kindled as long ago as the early 60s, when most amateur organs then in existence had been built using double triodes. I have, stashed away in the loft, several keyboards salvaged from the death-throes of superannuated pianos, but for the present content myself (at least until I retire and have a little more free time) with experimenting with voicing circuits, tone-forming filters, chiff generators and such like. The trouble is that there is never a good time to start, for the reasons mentioned above. First it was better to wait until transistors could be used instead of valves, then until



ICs could replace transistors. Then came wonderful do-it-all circuits that simplified matters no end – until they became obsolete and unobtainable: what a good job I still delayed. With "keyboards" of varying degrees of sophistication, not to mention complication, now available comparatively cheaply, it is perhaps only the dedicated constructors who will persevere. If all you want is 57 varieties of ready made left-hand accompaniment/rhythms together with a collection of preset voices (some reasonably realistic imitations of orchestral instruments, others frankly weird) for the right hand, then there is no point in building. However, for the purist I guess there is no substitute for the true chorus effect provided by banks of independent tone generators, analogous to all the ranks of pipes in a real pipe organ.

Regular readers of these lines will have heard me mention Fred, who had a radio shop in L------ Road. I don't remember too much about it as the Point Contact who frequented it on a Saturday afternoon was only a wee lad, just graduating from a crystal set to a 'one valver'. (This entailed the enormous expense of a 90V HT battery and a 2V accumulator, the need for which my mother just could not understand, when I already had a perfectly good crystal set.) But I do remember that, despite his ingenious ways with wireless repairs, Fred always kindly encouraged my interest in electronics. The other thing I remember is that his clock was nearly always wrong. For it was an electric clock – a rarity in those days – and this was just after the Second World War. Load shedding and voltage reductions during the day meant that generators were run at less than 50Hz, catching up over night ready for the next day. Electric clocks were thus usually about twenty minutes fast in the early morning, sagging with the effort to about twenty minutes slow at the end of the day, at least in cold weather. A few years later, by which time I had transferred my allegiance to Charlie's radio shop in K------- Road, things had improved a lot, though he did not have an electric clock since that area of town was on DC mains.

Yours sincerely,

Point Contact

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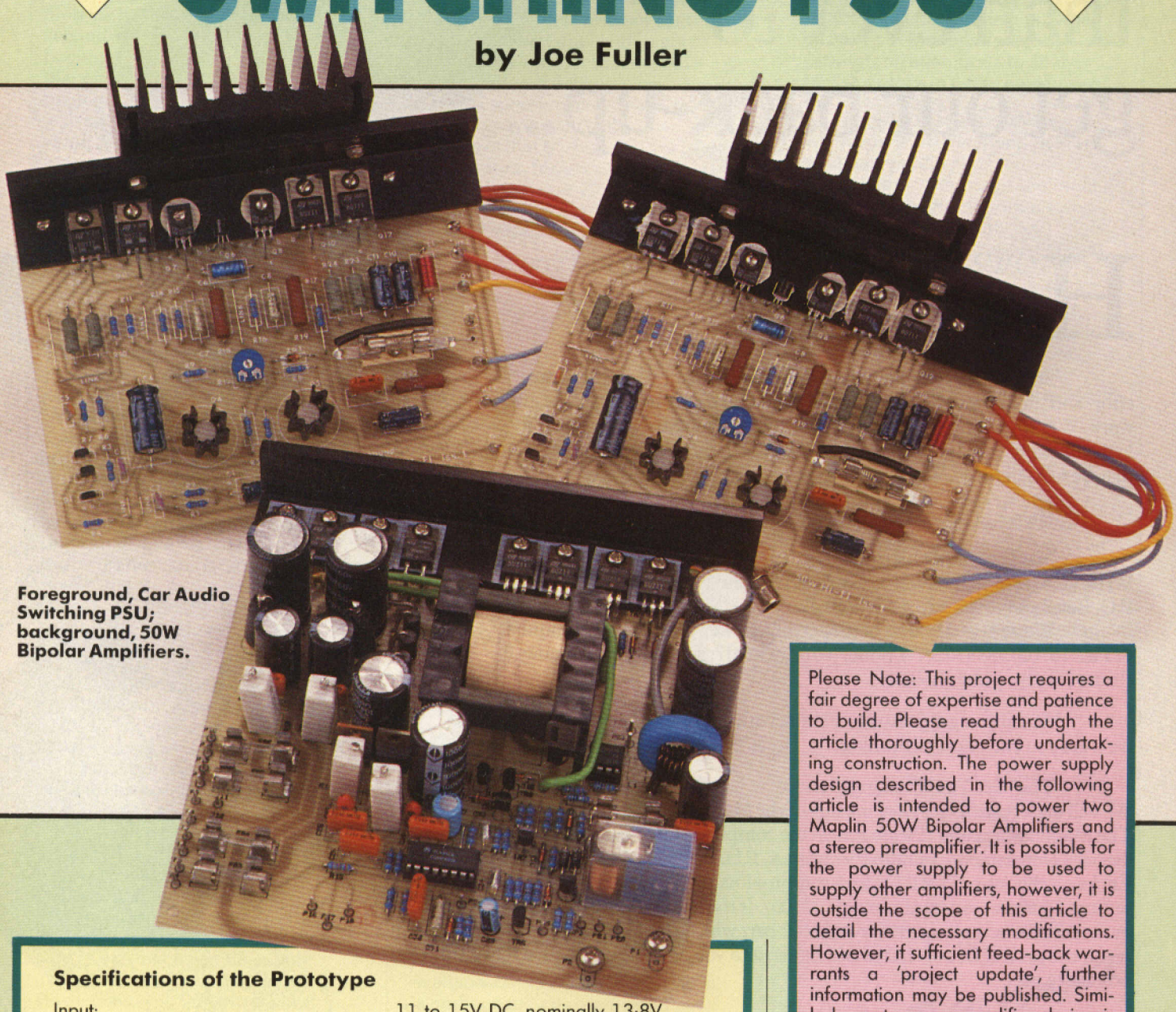
CAR AUDIO SWITCHING PSU

by Joe Fuller



Foreground, Car Audio Switching PSU; background, 50W Bipolar Amplifiers.

Please Note: This project requires a fair degree of expertise and patience to build. Please read through the article thoroughly before undertaking construction. The power supply design described in the following article is intended to power two Maplin 50W Bipolar Amplifiers and a stereo preamplifier. It is possible for the power supply to be used to supply other amplifiers, however, it is outside the scope of this article to detail the necessary modifications. However, if sufficient feed-back warrants a 'project update', further information may be published. Similarly, a stereo preamplifier design is not presented, although information may be published in response to feed-back. It is important to realise that the power supply is specifically tailored for audio applications and is, for a variety of reasons, not intended as a general purpose power supply.

Specifications of the Prototype

Input:	11 to 15V DC, nominally 13·8V
Input current (P_O = 116W):	10·7A (V_S = 11·3V)
Output Power:	120W continuous, see note below
Outputs	
Main:	±30V
Auxiliary:	±12V
Continuous Output Current	
±30V	2 + 2A
±12V	50mA + 50mA
Efficiency:	>90%
Thermal shut-down temperature:	80°C
Thermal shut-down hysteresis:	20°C
Standby input:	Active low
Remote switch-on input:	Active high
Thermal shut-down output:	Active low
Input noise (Po = 120W):	140mV
Output noise (Po = 120W)	
Main:	60mV
Auxiliary:	40mV
Switching Frequency:	25kHz
Converter mode:	Push-Pull

Note:

The supply is capable of delivering instantaneous power levels much higher than the continuous rating, which is ideal for audio applications where the peak current requirement, due to transients, is much higher than the average current requirement. Higher levels of power may be drawn as long as the average power is maintained at 120W. The figure of 120W is based on maintaining a heatsink temperature at less than 65°C.

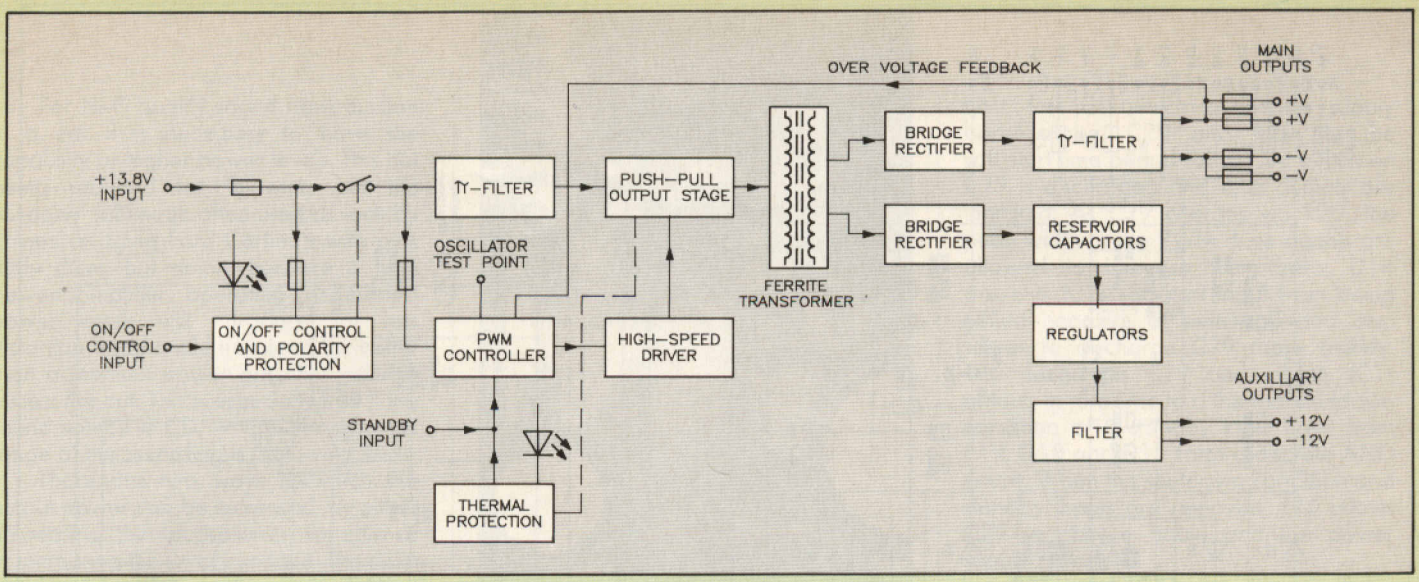


Figure 1. Block diagram of the switching PSU.

FEATURES

★ **Designed for high quality in-car entertainment systems**
★ **Polarity protected** ★ **Remote switch-on** ★ **Thermal protection**
★ **Input and output π-filters** ★ **Regulated ±12V auxiliary output for preamplifiers** ★ **±30V main outputs specifically intended for a pair of Maplin 50W bipolar amplifiers**

Introduction

For many years the motorist has not been able to benefit from Hi-Fi quality sound whilst travelling in the car. For the long-distance traveller, business executive or Hi-Fi buff on-the-move, the car is a far from ideal environment for listening to music; this is due to a number of reasons. Firstly, the car's interior is designed for conveying passengers and not for ideal location of conventional 'box design' loudspeakers. Secondly, the sound re-play/receiving equipment has to be miniaturised and capable of operation in a very harsh environment. Dashboard temperatures often exceed 60°C in hot weather (yes, even in the English climate!) and fall to several degrees below zero in cold weather. Vibration and humidity also add to the stresses that the equipment must endure. Thirdly, the low, noisey and somewhat variable supply voltage makes life even more difficult for the electronic circuitry.

The environmental and size problems of the car environment have largely been solved by cleverly designed equipment. Car loudspeakers are optimised for operation in rear parcel shelves and door panels instead of conventional sealed or ported enclosures. Car Radio, cassette, CD (Compact disk) and DAT (digital audio tape) equipment is very compact. Such equipment is designed for either mounting in the dash-board/centre console or remote mounting in the boot or under a seat, with just the controls located within the driver's easy reach.

It is however, the third point that is the main reason for this project, the vehicle electrical supply. The 12V electrical system is far from ideal when it comes to powering audio amplifiers. The electrical system itself, although generally referred to as being 12V, usually operates at around 13 – 14V when the engine is running. By convention, the voltage when the engine is running is assumed to be 13·8V.

A singled ended amplifier operating from a supply voltage of this (low) level is capable of delivering around 7W RMS into a 4Ω load. If a BTL (bridge tied load) amplifier is used the power output can be increased to around 22W RMS into a 4Ω load. Most 'high power' radio/cassette players have an output power of around 22W RMS, regardless of how many watts the advertising brochures boast!

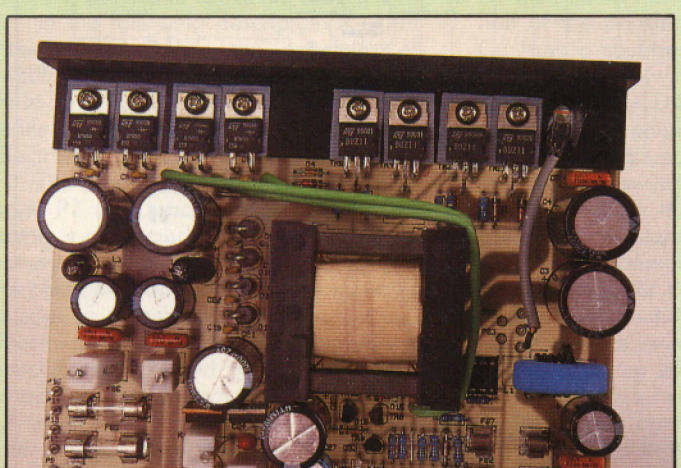


Photo 1. Close-up of heatsink assembly.

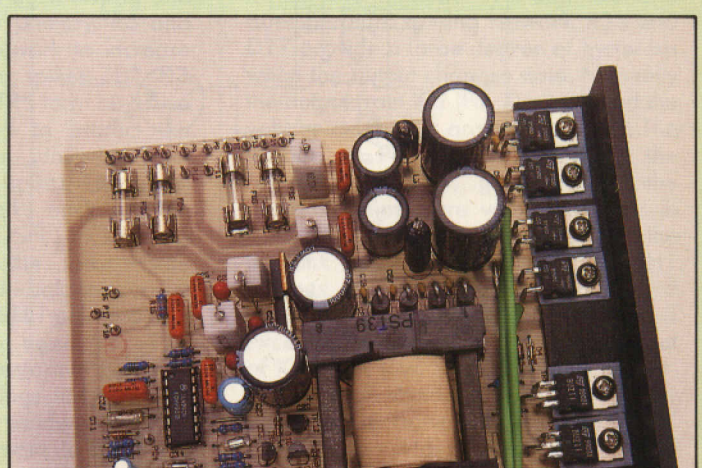


Photo 2. Close-up of the regulators, resistors and inductors.

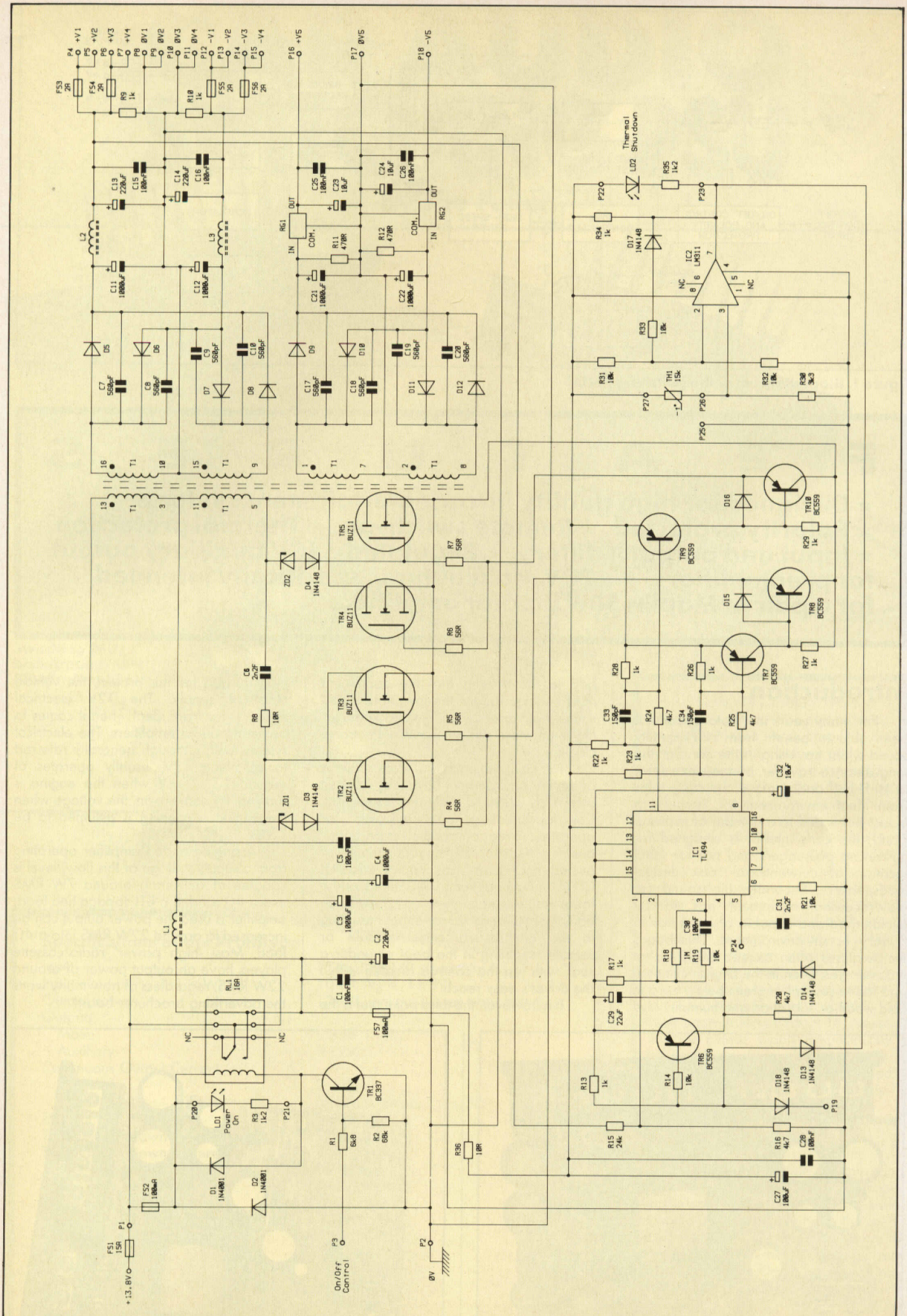


Figure 2. Circuit diagram of the switching PSU.

For Hi-Fi quality sound reproduction in a car it is necessary to have the capability of higher power levels. This not being required for 'blowing out the windows' (although often used as such by drivers of aging Ford Cortina's with pink fluffy dice), but simply because a high power amplifier operating at modest power levels will introduce far less distortion and handle transients far better than a medium power amplifier running almost flat out. This is especially true if the sound source is CD, where the dynamic range of the recording is often very wide.

There are two ways in which the output power can be increased, by either decreasing the loudspeaker impedance or increasing the supply voltage. The main disadvantage of the former method is that car speakers are not commonly produced with impedances below 4Ω and that power losses in cables are increased. The latter method of increasing the supply voltage is commonly used in high power car 'boosters' and in Hi-Fi car audio amplifiers, this is the method that is described here.

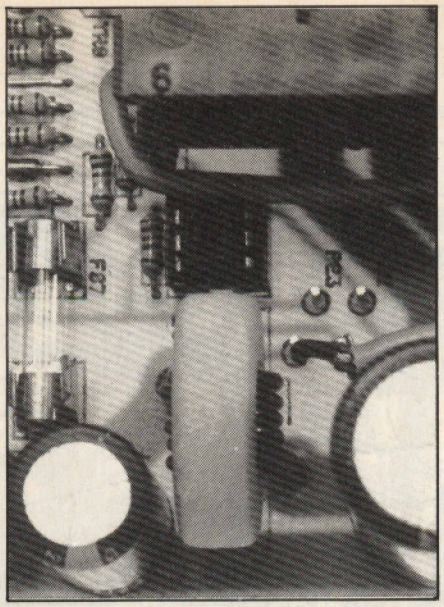


Photo 3. Close-up of the toroid inductor fitted into the PCB.

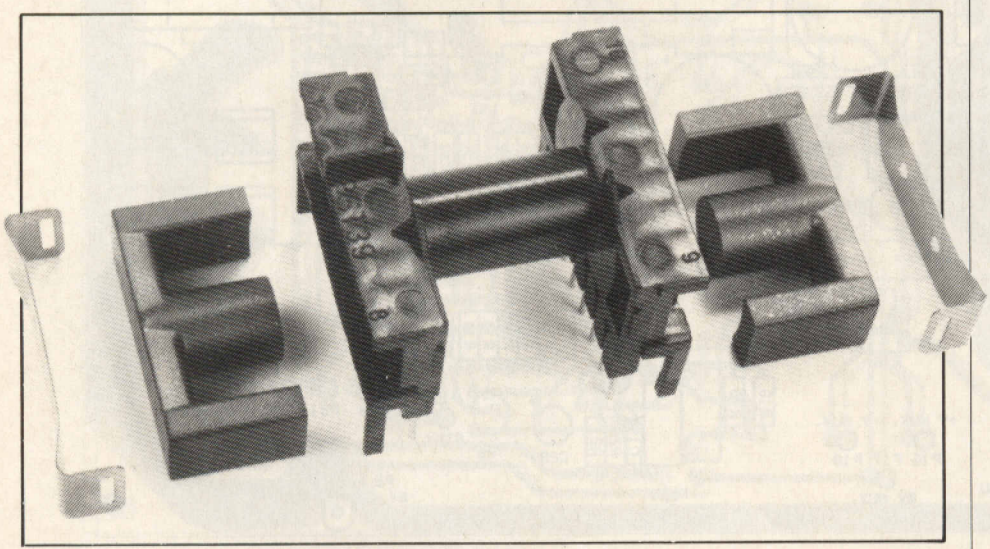


Photo 4. The component parts of the ferrite transformer.

Circuit Description

Figure 1 shows a block diagram representation of the power supply and Figure 2 shows the full circuit diagram.

In the following description it is not intended to explain the principles of switched mode power conversion since these have been adequately covered by a series on this topic, see issues 37 to 39 of 'Electronics'.

The supply input to the power supply is via P1 (+V) and P2 (0V). The power supply is connected directly to the vehicle battery via high current cables, therefore the off-board supply fuse FS1 is essential in case of a fault causing a short circuit directly across the battery. Remote power switching is achieved by TR1, RL1 and associated components. The control input P3, when taken to +V, biases TR1 on and operates RL1, thus powering-up the rest of the supply. LD1 serves to indicate 'power on'. The control signal is provided by the 'electric aerial' output found on most radio-cassette units. D1 clamps the voltage spike produced by RL1 when it de-energises. D2 provides polarity protection by blowing FS2 and preventing the remote power switch from operating.

C1, C2, C3, C4, C5 and L1 form the input π-filter, the output of which supplies the push-pull output stage. The Power MOSFETs are arranged in two pairs TR2 & TR3 and TR4 & TR5, each driving one half of the transformer primary. R8 and C6 form a snubber network to increase the rise-time of switching spikes. ZD1, D3 & TR2 and ZD2, D4 & TR5 form an active spike clamp, employed to protect the MOSFETs drain/source junctions from high voltage switching spikes. This operates by feeding the spike back into the gate of the relevant MOSFET thus turning it on and clamping the spike. Gate resistors R4 to R7 help to balance current flow through each MOSFET pair and also help to reduce switching noise.

T1 is a step up transformer comprising six windings, two connected to form a centre tapped primary winding and four are connected in two pairs to form two centre tapped secondary windings.

R36, C27 and C28 form a simple R-C filter for IC1 which attenuates supply borne noise. C29 and R20 set the soft-start time period for IC1. At switch on C29 is discharged and IC1s outputs are inhibited. As C29 charges via R20, the pulse width of the PWM drive signals are allowed to increase from zero. D14 prevents IC1s soft-start input from being pulled negative at switch-off and also serves to discharge C29 more quickly. TR6 discharges C29 and inhibits IC1s outputs in response to a thermal shutdown condition or a standby input (low) from P19. D18 and D13 form a discrete AND circuit. When the shutdown condition and standby inputs are removed, TR6 allows C29 to charge again and the power supply restarts.

R21 and C31 set the oscillator frequency, P24 may be used to monitor the oscillator waveform. Care should be exercised to ensure that this pin is not subject to undue capacitive loading, otherwise the oscillator frequency will shift.

R17, R18, R19 and C30 form a phase selective network that sets the gain of the over-voltage amplifier. Phase compensation is necessary to ensure good loop stability, otherwise the power supply could break into oscillation. R15 and R16 form a potential divider which is used to apply over voltage feedback to IC1, with the values as shown, the maximum output voltage is ±30V.

TR7 to TR10 and associated components form two high speed driver circuits which are able to charge and discharge the gate capacitance of each of the MOSFETs very quickly. Circuit operation for one of the (two identical) drivers is as follows: R23 is the pull-up resistor for the open collector output of IC1 (pin 8). When pin 8 goes low (output on) TR7 is biased on by R25 (C34 serves to increase switching speed), D15 conducts and TR2, TR3 turn on quickly. At this time TR8 is switched off. When IC1 pin 8 goes high (off) TR7 switches off and TR8 base is pulled low; since the gates of TR2 and TR3 are charged to a positive potential, D15 is reverse biased and TR8 conducts. This action rapidly switches off TR2 and TR3.

IC2 is a comparator with its inputs connected to two potential dividers. R31 and R32 form a reference potential divider and thermistor TH1 and R30 form a temperature sensing network. R33 and D17 provide a large degree of hysteresis when the output changes state. Normally the output from IC2 (Pin 7) is high and the voltage on Pin 2 is around ½ supply. The voltage on Pin 3 is dependent on the resistance of TH1, governed by the heatsink temperature with which it is in contact. As the temperature of the heatsink rises, the resistance of TH1 reduces and the voltage on Pin 3 increase. When the voltage on Pin 3 exceeds the voltage on Pin 2, the output of IC2 goes low. LD2 illuminates indicating thermal shutdown and the power supply shuts down. At this point D17 conducts, this adds R33 to the lower half of the reference divider reducing the reference potential on Pin 2 to around ⅓

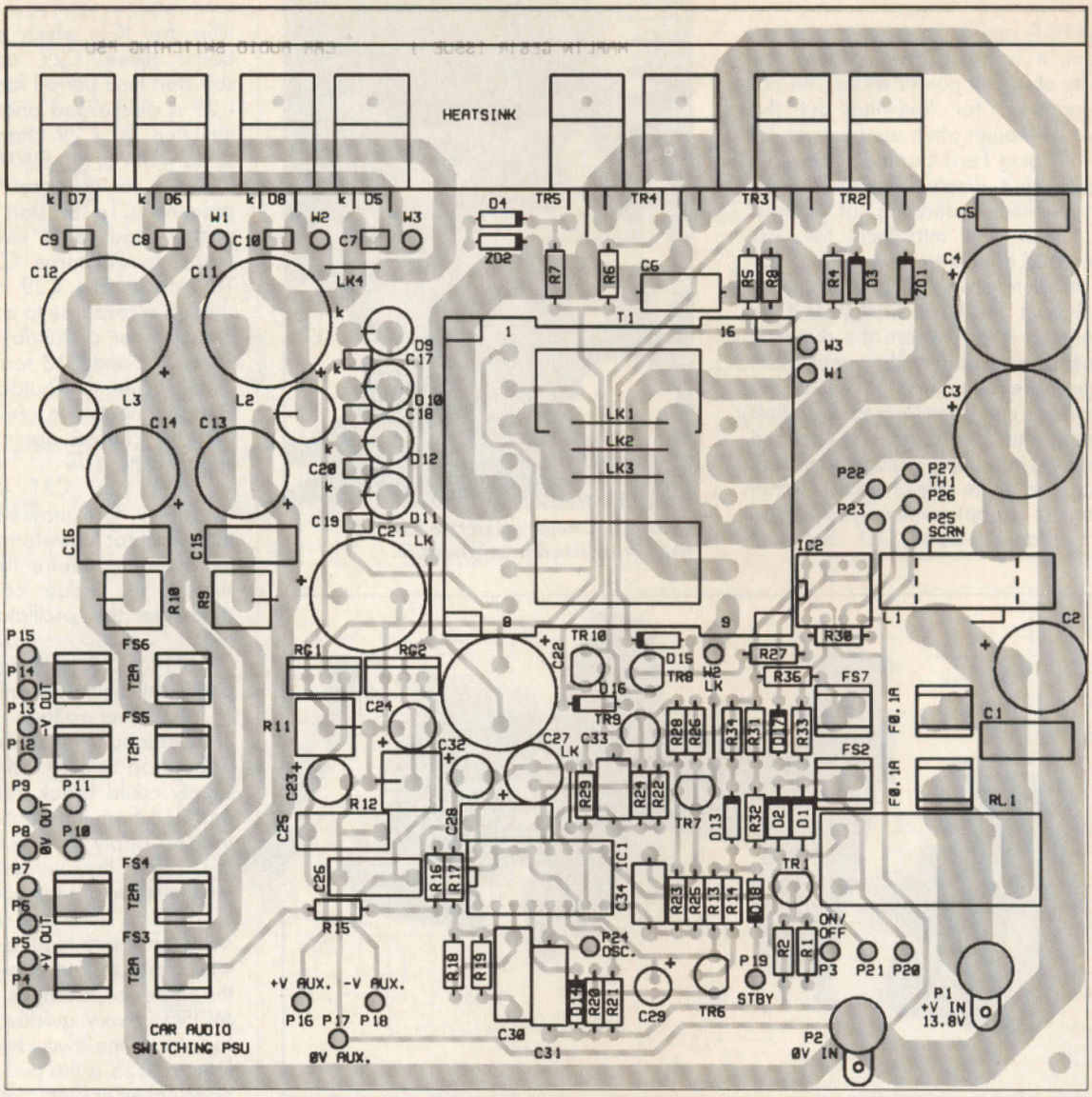


Figure 3. PCB legend and track.

supply (ignoring D17 voltage drop and saturated output voltage of IC2). The voltage on Pin 3 will now have to fall below ⅓ supply before the circuit will reset and the supply allowed to restart. Correspondingly the resistance of TH1 will have to rise and its temperature fall before supply operation is resumed. With the circuit values as shown, the trip temperature is 80°C and the reset temperature is 60°C.

D5 to D8 form a bridge rectifier (main output), the devices used are high speed types, essential for use in switch mode applications. C7 to C10 help to reduce transients and switching noise. C11, C12, L2, L3, C13, C14, C15 and C16 form π-filter networks for the main outputs. R9 and R10 serve to provide a 'minimum load' for the power supply and also discharge the filter capacitors quickly after switch-off. FS3 to FS6 provide protection against short circuits and overloads. Positive 30V outputs are available from P4, 5, 6 and 7. Negative 30V outputs are available from P12, 13, 14 and 15. Pins 8, 9, 10 and 11 provide a zero volt return.

D9 to D12 form a second bridge rectifier (auxiliary output), again high speed types are used. C17 to C20 help to reduce transients and switching noise. C21 and C22 are the reservoir capacitors for the auxiliary output. R11 and R12 serve the same purpose as R9 and R10 in the main output circuitry. RG1 and RG2 regulate the supply rails and attenuate switching noise on the auxiliary output. C23, C24, C25 and C26 are decoupling capacitors and ensure supply stability. Positive and negative 12V auxiliary outputs are available on P16 and P18 respectively. P17 provides a 0V return.

Construction

The PCB is of the single-sided glass fibre type, with a printed legend to assist insertion of the components. To increase the current rating of some of the tracks it is necessary to tin the exposed areas of track on the underside of the PCB. These tracks will be clearly seen as they are not covered by the solder resist layer. Tinning of the tracks should be the final assembly task. Removal of misplaced components can be very difficult, especially on a densely populated board such as this, so please double check component type, value and orientation (where appropriate) before inserting and soldering the component.

Referring to the following constructional notes, the parts list and Figure 3, begin construction. It is recommended that the following construction order is adhered to closely, otherwise it will be found extremely difficult, to fit some of the components.

Start by inserting the three 22SWG wire links, these are indicated on the PCB by a single straight line and an adjacent 'LK' mark.

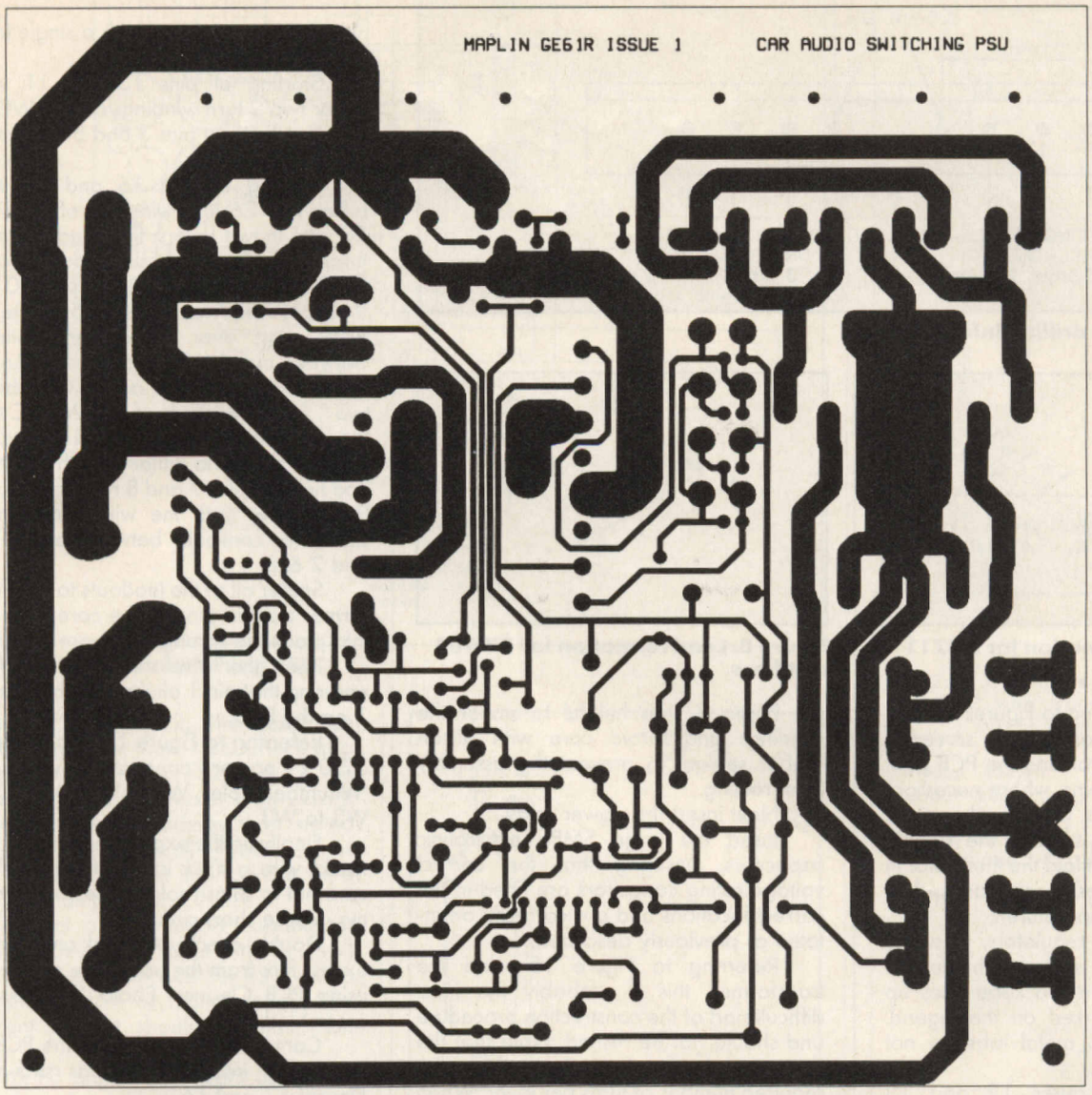
Next insert the 1N4148 signal diodes, ensuring correct orientation.

Insert 0·6W Metal Film resistors, do not insert the 3W wire wound resistors at this stage.

Bend and insert the four 16SWG wire links, these are indicated on the PCB by a single straight line and an adjacent 'LKnumber'.

Next insert the 1N4001 diodes and the two 39V zener diodes.

Referring to Figure 4, loosely fit the M3 power input connection hardware and solder the M3 nuts to the PCB pads.



Insert the polystyrene capacitors and the ceramic capacitors.

Next insert the DIL sockets, do not insert the ICs at this stage.

Insert the 45(!) PCB pins into the holes for TR2 to TR5 and D5 to D8; and positions marked with a circle and a 'Pnumber'. Do not insert pins into positions marked with a circle and a 'Wnumber',

Next Insert the fuse clips, it will be found that by carefully bending over the two legs on the track side of the PCB before soldering, the fuse clips will remain straight.

Insert the BC337 and BC559 transistors, ensuring correct orientation.

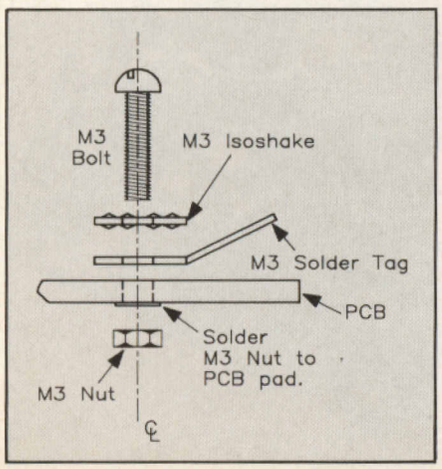


Figure 4. Power input connection assembly.

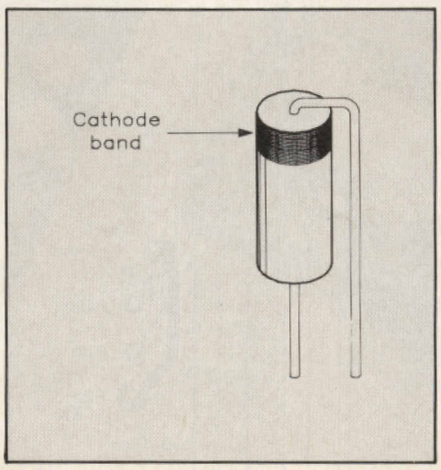


Figure 5. Lead formation for BYW98 rectifiers.

Next insert the tantalum capacitors, ensuring that the correct voltage rating capacitor is inserted in the correct location. The tantalum capacitors are polarised and must be correctly orientated, the plus (+) sign on the body must be inserted into the hole nearest that marked with a plus sign.

Form the leadouts of the BYW98 rectifier diodes, as shown in Figure 5 and insert these into the PCB. Ensure that the cathode lead, which is indicated by a band around the component body is inserted into the hole nearest that marked with a 'k' sign.

Insert the 0·1 μF poly layer capacitors and the small electrolytic capacitors. The electrolytic capacitors are polarised and must be correctly orientated, the negative (−) stripe on the capacitor can must be inserted into the hole furthest away from the hole marked with a plus (+) sign.

Drill the heatsink as shown in Figure 6. Form the leads of the BUZ11 MOSFETs and the BYW80 rectifiers as shown in Figures 7 and 8. Assemble the heatsink assembly using the M2·5 hardware as shown in Figure 9 and Photo 1. Solder the leadouts of the transistors and rectifiers to

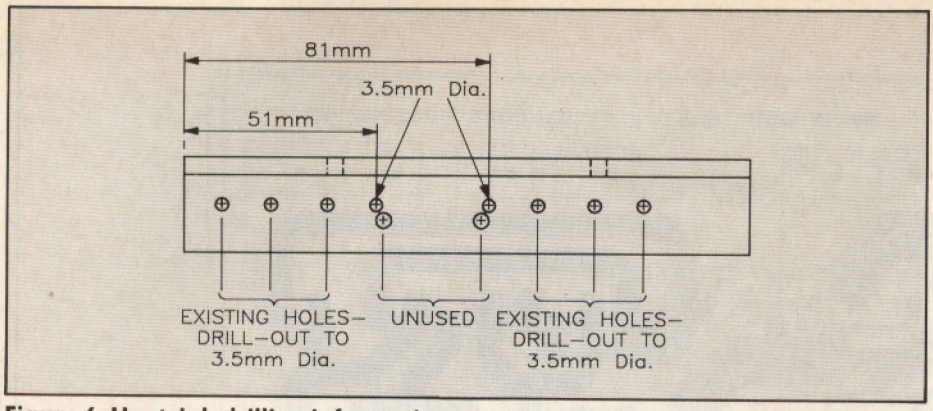


Figure 6. Heatsink drilling information.

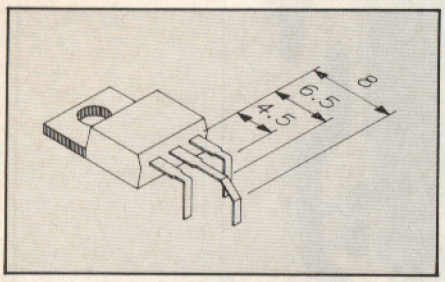


Figure 7. Lead formation for BUZ11 MOSFETs.

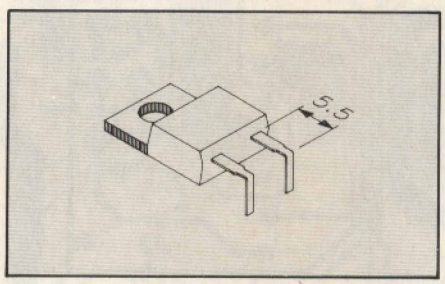


Figure 8. Lead formation for BYW80 rectifiers.

the PCB pins. Referring to Figures 10 and 11 and Photo 1, connect the screened cable to the thermistor and the PCB pins, use heat shrink sleeving where necessary to avoid short circuits. Glue the thermistor to the heatsink using some of the 'double bubble' epoxy resin. Hold the thermistor in place whilst the resin sets (around 5 minutes at room temperature).

Insert the two regulators, ensuring that the correct type is fitted in the correct location and that the package lines up with the outline marked on the legend. Ensure that the two metal tabs do not touch, see Photo 2.

Referring to Figures 12 and 13 extend the leadouts of the 3W resistors and axial inductors and insert these into the PCB, see Photo 2.

Referring to Figure 14 wind 2½ turns of two lengths of 16SWG EC wire wound bifilar (side by side) around the toroid core. Prepare the ends of the EC wire to facilitate soldering and insert this inductor into the PCB at the position marked L1, see Photo 3. It is helpful to smear the windings and toroid core with silicon rubber sealant to prevent the assembly from rattling.

Next insert the power relay.

Insert the large SMPS electrolytic capacitors, ensuring that the correct voltage rating capacitors are fitted in the correct locations and are correctly orientated as previously described.

Referring to Figure 15 wind the transformer, this is probably the most difficult part of the construction procedure and should not be rushed. Note that the diagrams do not figuratively show the required number of turns per layer. When winding the transformer take care not to over stress the bobbin otherwise pins may break off – use pliers to carefully bend the wire around the pins. It will be necessary to remove the enamel coating from the wire to allow soldering, emery paper is ideal for this. Photo 4 shows an exploded view of the component parts of the transformer.

Cover each layer with a single layer of masking tape.

Starting at pins 13 and 11 wind bifilar two 9 turn windings of 18 SWG EC wire first finish at pins 3 and 5 respectively, see Figure 15a.

Starting at pins 16 and 15 wind bifilar two 26 turn windings of 20 SWG EC wire in two layers; first wind bifilar 13 turns, see Figure 15b. Wind bifilar a further 13 turns and finish at pins 10 and 9 respectively, see Figure 15c, note the wires cross over. Check for continuity between pins 16 & 10 and 15 & 9.

Starting at pins 1 and 2 wind bifilar two 15 turn windings of 20SWG EC wire in two layers; first wind bifilar 13 turns, see Figure 15d. Wind bifilar a further 2 turns and finish at pins 7 and 8 respectively, see Figure 15e, note the wires cross over. Check for continuity between pins 1 & 7 and 2 & 8.

Solder all of the leadouts to the transformer bobbin pins, fit the cores and clip into place the sprung steel core retainers.

Insert the transformer into the PCB, ensuring that pin 1 aligns with the number 1 on the PCB.

Referring to Figure 11 and using the 32/0·2 power connection wire, link 'Wnumber' holes; W1 to W1, W2 to W2, W3 to W3.

Finally tin the exposed lengths of PCB tracks with a *thick* layer of solder. Take care not to splash solder elsewhere which may cause short circuits.

Double-check your work and remove excess flux from the underside of the PCB using PCB Cleaner. Photo 5 shows the assembled PCB.

Connect the two LEDs to the PCB via lengths of insulated wire as shown in Figures 11 and 16.

Testing

Figure 11 shows the location of the input and output connections referred to in this section.

Fit IC1, IC2 and the fuses.

Using a multimeter on a suitable resistance range, measure the resistance

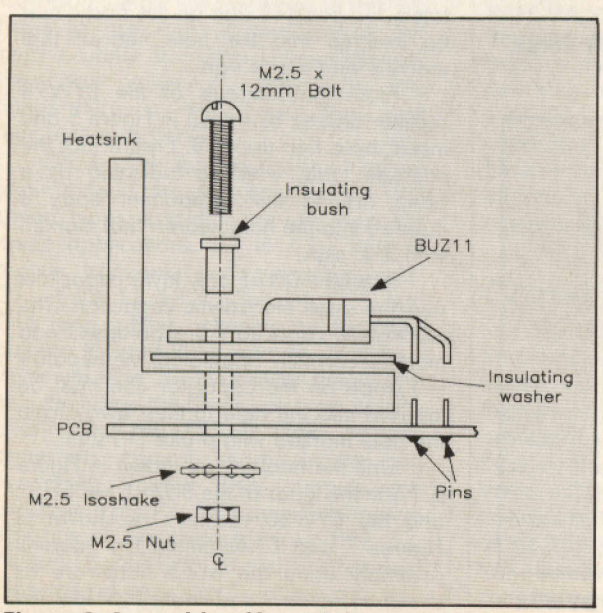


Figure 9. Assembly of heatsink components.

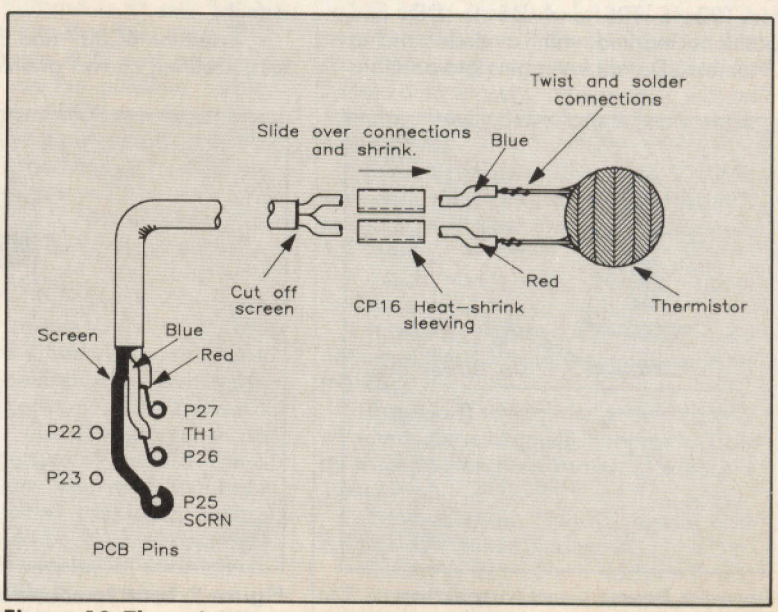


Figure 10. Thermistor connection.

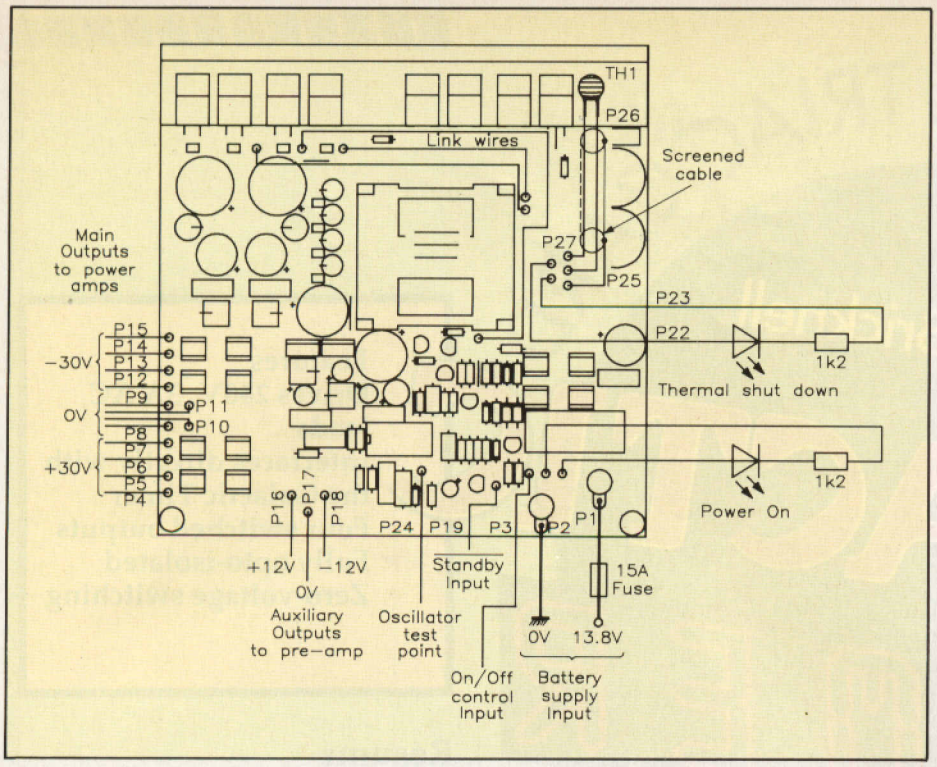


Figure 11. Wiring to switching PSU.

between FS7 and P2, the resistance should be greater than 2kΩ. Check also the resistance between FS2 and P2, the resistance should be greater than 2kΩ. If significantly lower readings than stated are measured, recheck all of your work as there is likely to be a short circuit or a misplaced component.

Connect a 12V supply capable of delivering 5A to the input pins P1 (+V) and P2 (0V) via a 5A fuse (for FS1) and a multimeter on 5A or higher range. The quiescent current should be less than 1mA.

Link P3 and P1 with light duty wire, whereupon the relay should energise and the power-on LED (LD1) should illuminate. The current indicated on the meter should

Continued on page 44

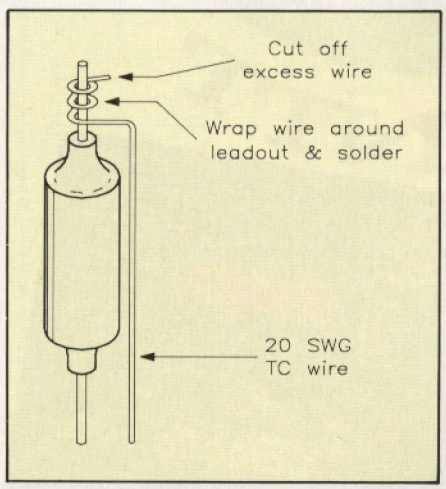


Figure 12. Extending leadouts of axial inductors.

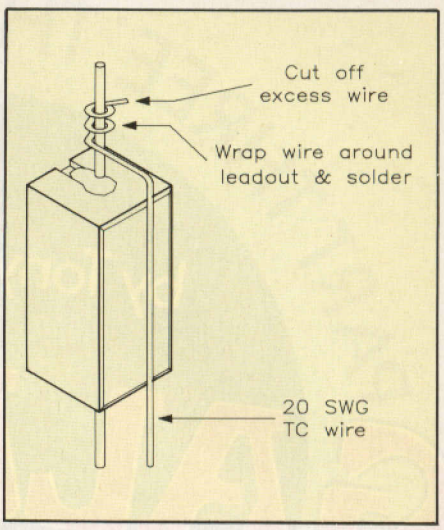


Figure 13. Extending leadouts of axial resistors.

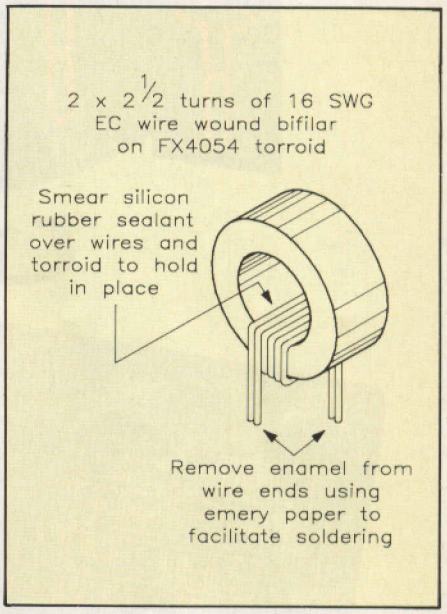

2 x 2 1/2 turns of 16 SWG EC wire wound bifilar on FX4054 torroid
Smear silicon rubber sealant over wires and torroid to hold in place
Remove enamel from wire ends using emery paper to facilitate soldering

Figure 14. L1 winding information.

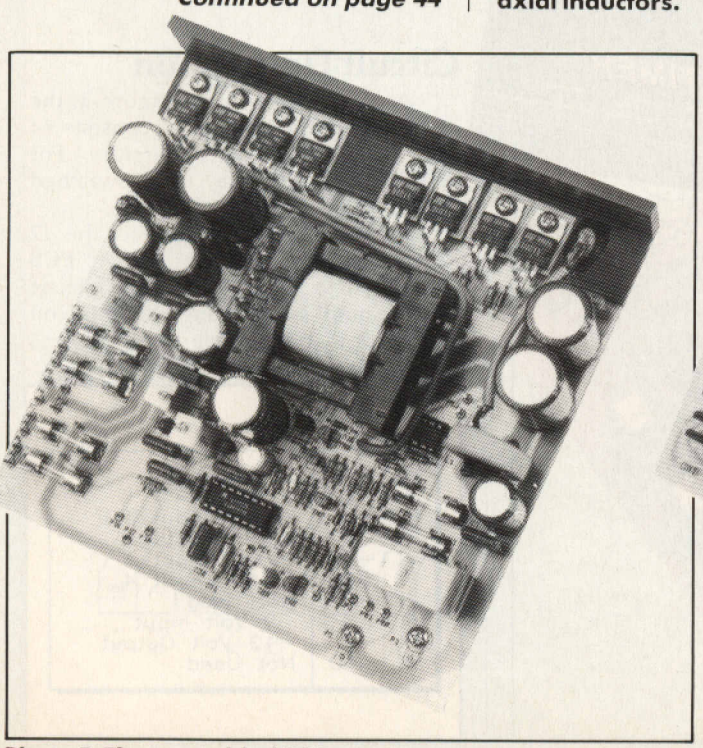


Photo 5. The assembled PCB.

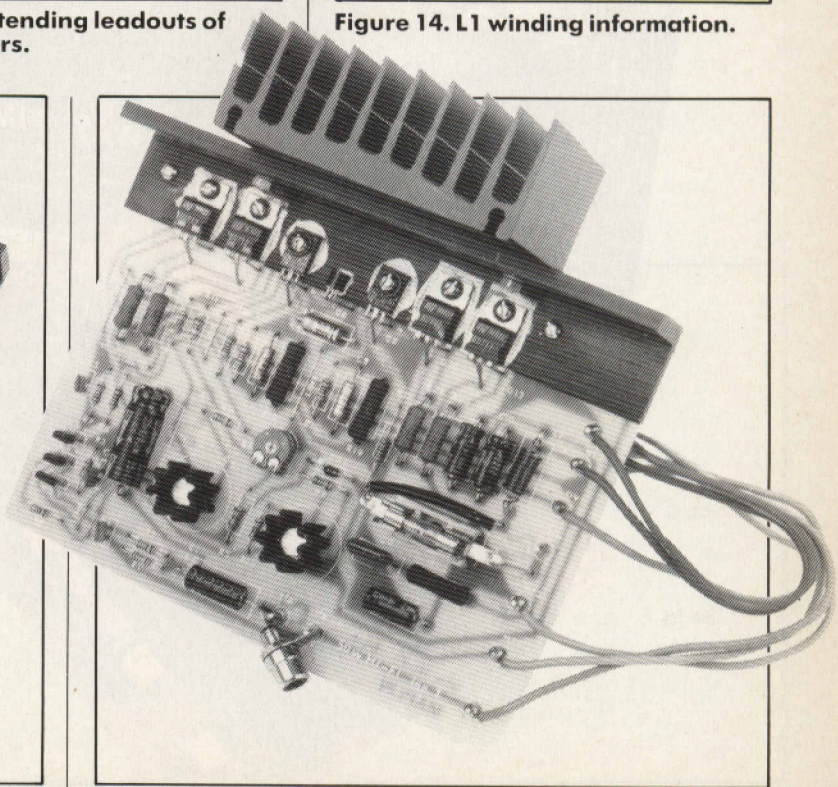


Photo 6. Maplin 50W Bipolar Amplifier.

PART THREE: THE TRIAC CARD

GALACTIC TIMER UNIT

by Tony Bricknell

Features

- ★ Drives 240V, 3A AC loads
- ★ Interfaces directly with the Galactic Timer
- ★ Four switched outputs
- ★ Fully opto-isolated
- ★ Zero-voltage switching

Résumé

In Issue 44 of *'Electronics'*, the construction of the Galactic Timer, a timer that will control four outputs by time of day or week, was described. The timer switches its outputs on times entered through a keyboard and stored in battery backed-up memory. There are 28 switching times available to each output on a weekly basis and four on a daily basis.

The Galactic Timer is designed to be used with either:

a) A four channel relay board (Stock code LP26D). This is used for switching voltages up to 110V AC/24V DC @ 10A per output, and was described in the last edition of *'Electronics'*

b) A four channel triac board (Stock code LP27E). This is used for switching 240V AC @ 3A per output, and is described below.

Circuit Description

As can be seen from Figure 1, the circuit diagram effectively consists of four identical 'smaller' circuits. For simplicity, only the first switched output will be described.

P1 and P2 simply connect the 12 Volt output of the power supply PCB (described in Issue 44) to the Galactic Timer's main PCB, through the minicon connector PL1, see Table 1.

PL1–1	0 Volt
PL1–2	0 Volt
PL1–3	Switch Input 1
PL1–4	Switch Input 2
PL1–5	Switch Input 3
PL1–6	Switch Input 4
PL1–7	Not Used
PL1–8	–9 Volt Input
PL1–9	–12 Volt Output
PL1–10	Not Used

Table 1. Minicon connections.

Galactic Timer Unit and inset the Triac Card.

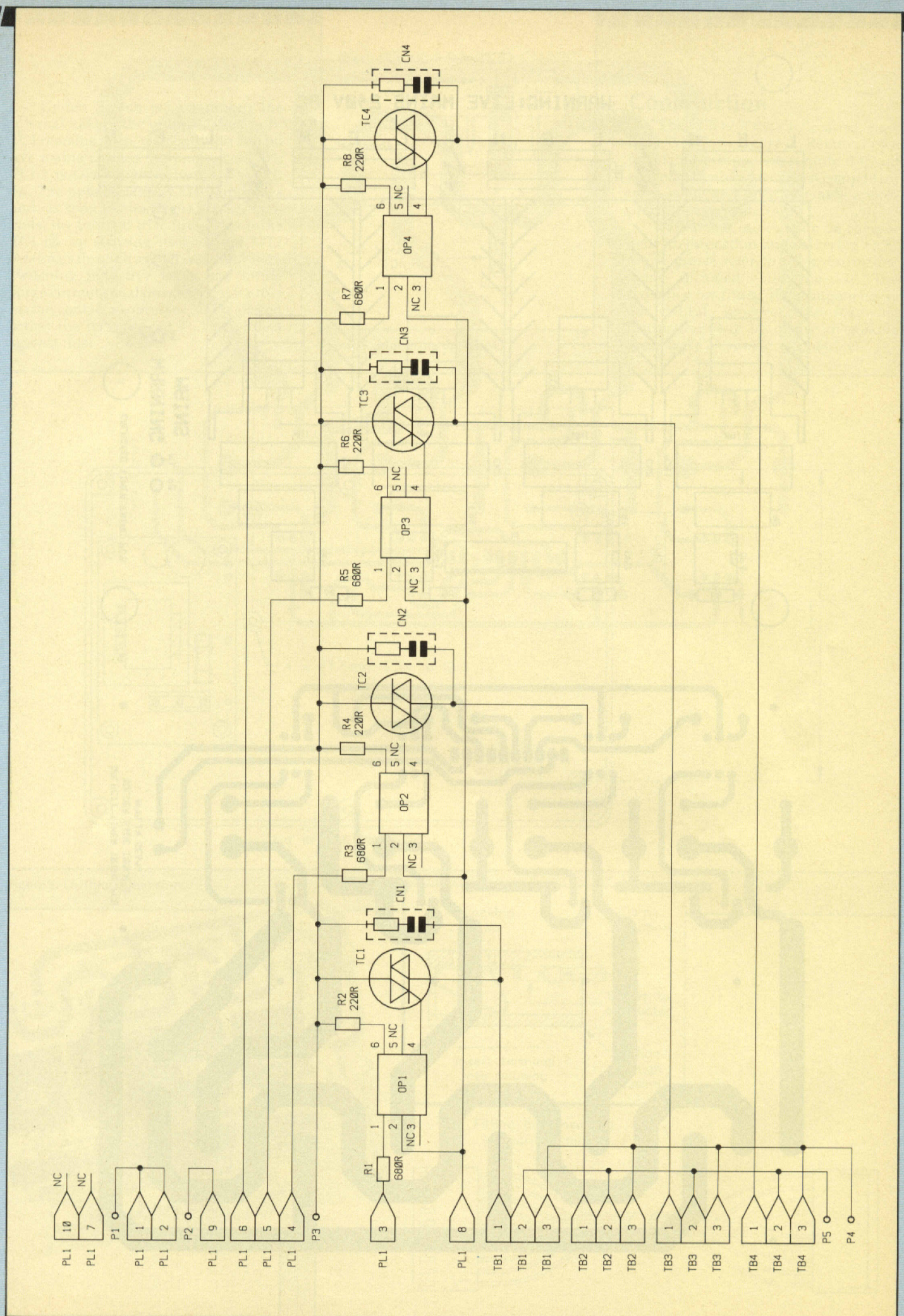


Figure 1. Circuit diagram.

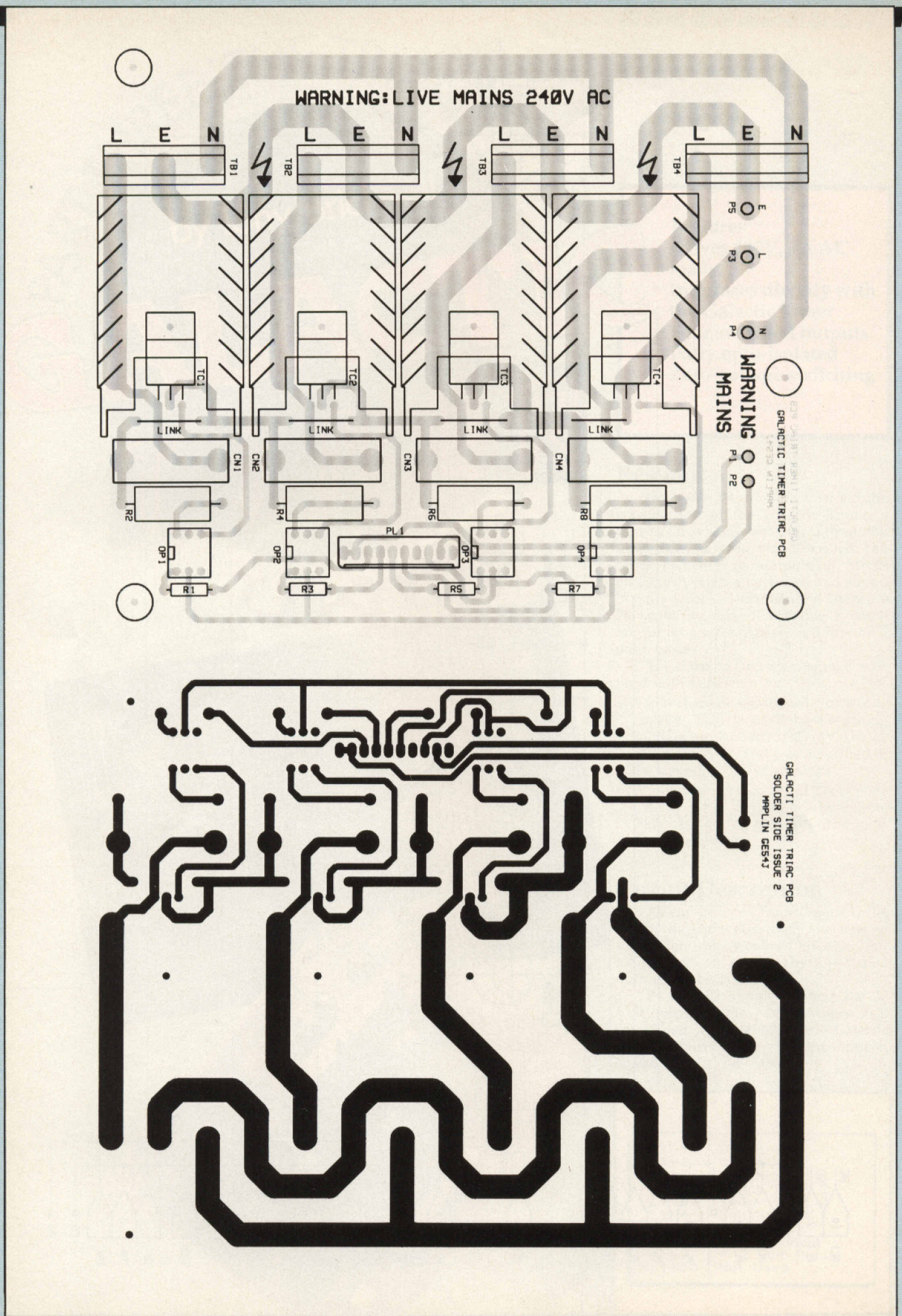


Figure 2. PCB layout.

Under 'Switch off' conditions the internal LED of the opto-isolator is off. TC1 remains in an 'off' condition and no live mains reaches terminal block TB1. PL1-2 is taken high to turn the switch on. The opto-isolators LED illuminates and, as soon as the mains crosses zero volts, the internal triac fires. This turns TC1 on by shorting its gate and MT2 terminals through a 220Ω resistor. When switching inductive loads, the initial surge current can damage triacs; for this reason contact suppressor SN1 is placed across the terminals of TC1 to protect against this.

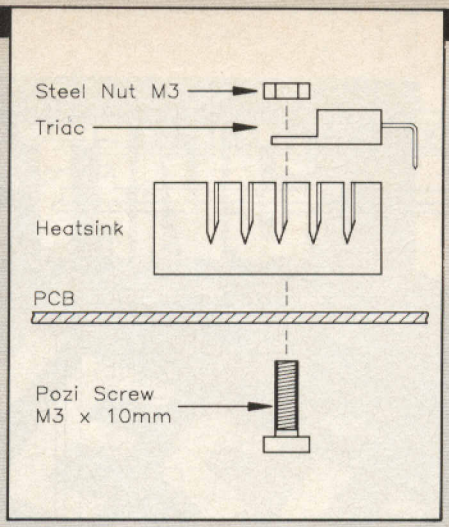


Figure 3. Mounting the triacs.

Construction

The PCB is of the single sided, glass fibre type, see Figure 2. Removal of a misplaced component is quite difficult so please double-check each component type, value and polarity where appropriate, before soldering!

For further information on component identification and soldering technique please refer to the constructors' guide included with the kit. The sequence for fitting the components is not critical, however, the following instructions will be of use in making these tasks as simple as possible.

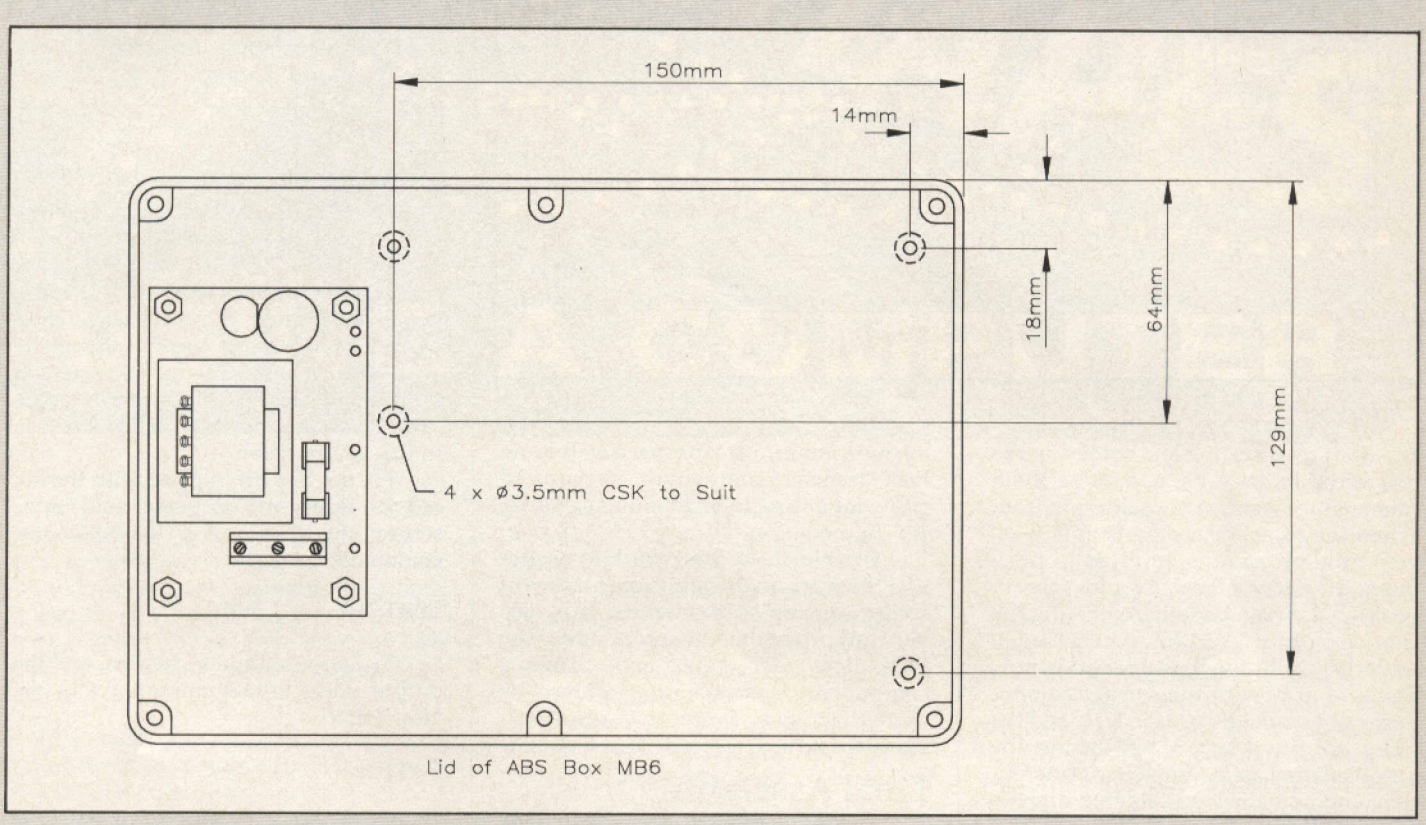
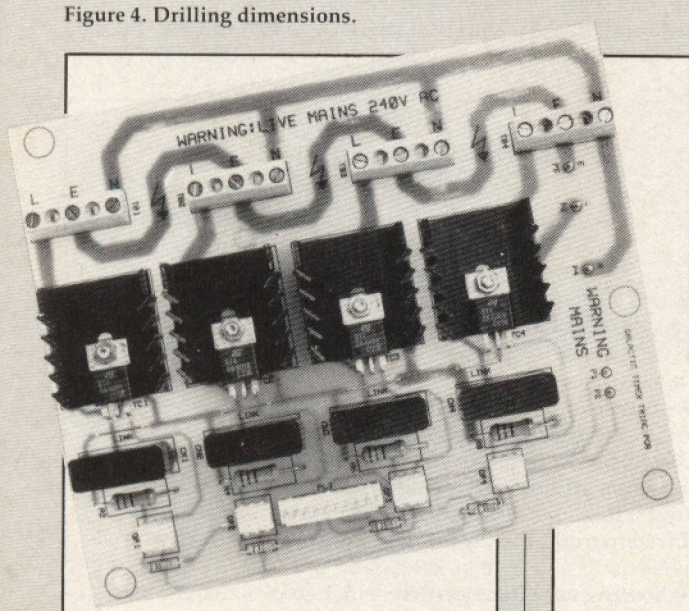
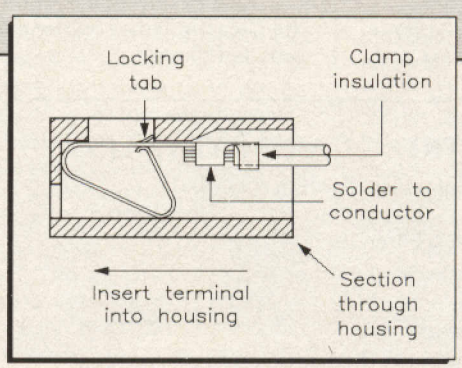


Figure 4. Drilling dimensions.



The Triac Card PCB.



Fitting and Inserting Minicon Terminals

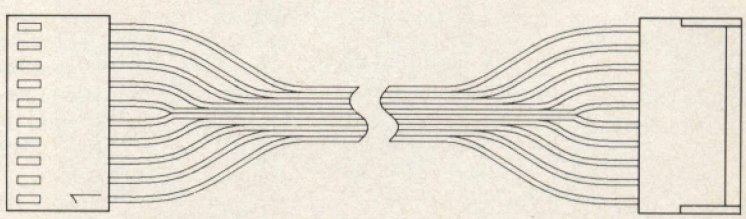


Figure 5. Interconnect cable.

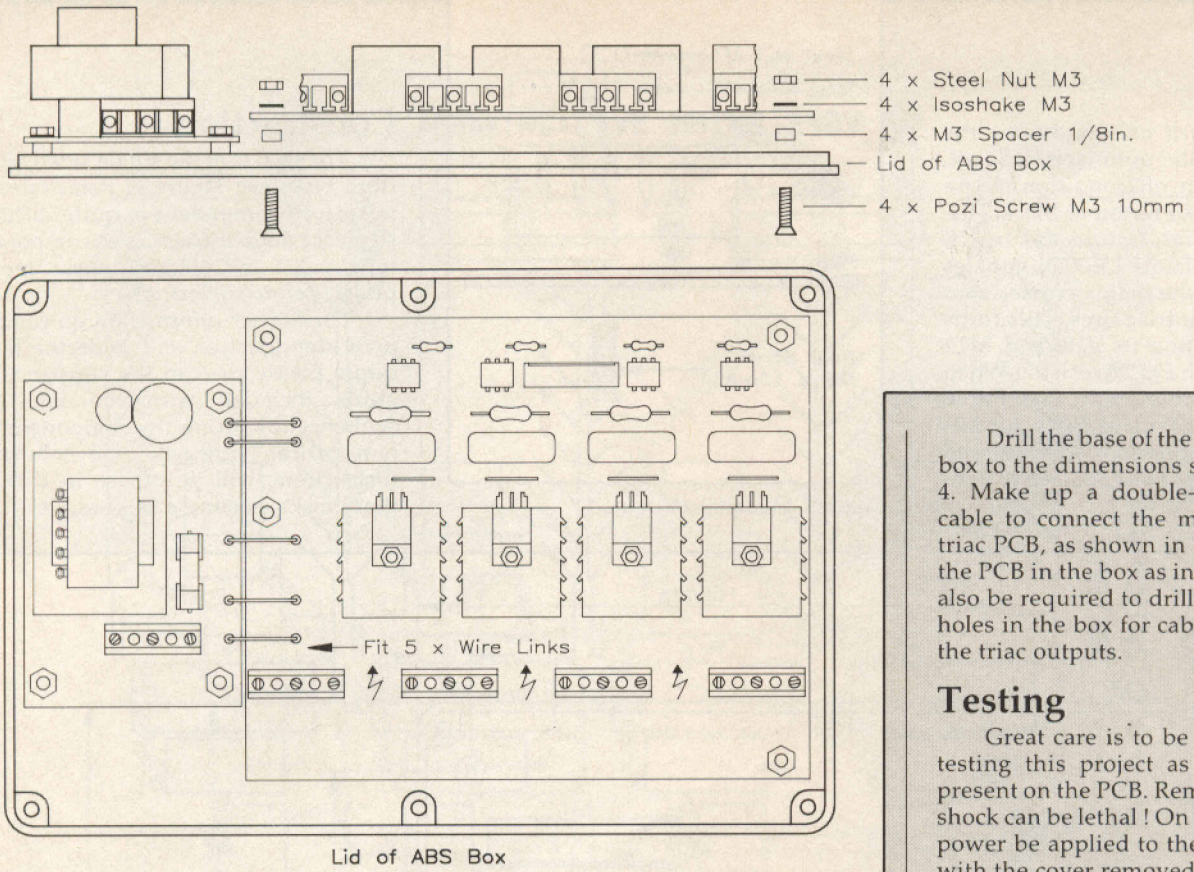


Figure 6. Fixing the PCB.

Start by inserting and soldering the five veropins P1 – P5, and press them into position using a hot soldering iron. When the pins are heated in this way, very little pressure is required to push them in place. Once the pins are in position they can be soldered. Using the short length of 22 SWG wire included with the kit, fit the four links. It is now easier to start with the smaller components and work upwards in size, and the triacs are fitted last. When fitting the opto-isolators, take care in their orientation, and note they are soldered directly to the PCB.

The triacs, being zero-voltage switched, dissipate very little heat and, as their mounting tabs are isolated, no heat transfer compound is required when mounting them to their heatsinks, see Figure 3.

Double-check your work to ensure that there are no dry joints or splashes of solder causing short circuits. It is also very important that the solder side of the PCB does not have any trimmed component lead standing proud by more than 3mm, as this may result in a short circuit.

Final Assembly

Ensure that power is removed from the Galactic Timer before modifying the unit as follows:

Drill the base of the Galactic Timer's box to the dimensions shown in Figure 4. Make up a double-ended minicon cable to connect the main PCB to the triac PCB, as shown in Figure 5, and fit the PCB in the box as in Figure 6. It may also be required to drill up to four extra holes in the box for cable connection to the triac outputs.

Testing

Great care is to be exercised when testing this project as 240V mains is present on the PCB. Remember, a mains shock can be lethal ! On *no* account must power be applied to the Galactic Timer with the cover removed from the box.

Connect four 240V mains devices to terminal blocks TB1 – TB4. If the mains device has an on/off switch, ensure it is in the 'on' position.

Fix the box lid in place with the six screws, apply mains power and, after setting the clock, enter the following command:

SWITCH 1 ON

Triac one should switch on, and the output status LED illuminate.
Now enter:

SWITCH 1 OFF

Triac one will switch off, and the output status LED extinguish. Repeat these operations for switches 2, 3 & 4.

GALACTIC TIMER TRIAC CARD PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1,3,5,7	680Ω	4	(M680R)
R2,4,6,8	220Ω 1W Carbon Film	4	(C220R)
CAPACITORS			
SN1–4	R-C Contact Suppressor	4	(YR90X)
SEMICONDUCTORS			
OP1–4	Zero Crossing Optotriac	4	(RA56L)
TC1–4	BTA08-600B Triac	4	(UK54J)
MISCELLANEOUS			
TB1–4	3-Way HV Terminal Block	4	(JR80B)
PL1	PCB Latch Plug 10-Way	1	(RK66W)
P1–5	Pins 2145	1Pkt	(FL24B)
	PCB Latch Housing 10-Way	1	(FY94C)
	PCB Minicon Terminals	1	(YW25C)
	Vert Vaned Hsk TO220	4	(JW29G)
	TC Wire 0·71mm 22swg	1Reel	(BL14Q)
	Pozi Screw M3 10mm	1Pkt	(LR57M)
	M3 Spacer ⅛in	1Pkt	(FG32K)
	Isoshake M3	1Pkt	(BF44X)
	Steel Nut M3	1Pkt	(JD61R)
	Galactic Tmr Trc PCB	1	(GE54J)
	Instruction Leaflet	1	(XT09K)
	Constructors' Guide	1	(XH79L)

The above items are available as a kit, which offers a saving over buying the parts separately.
Order As LP27E (Galactic Triac Card) Price £24.95
Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) are also available separately:
Galactic Tmr Triac PCB **Order As GE54J Price £6.25**

PREDICTING WAVESHAPES USING A COMPUTER

PART TWO
The Capacitor-Resistor Circuit

by Philip Lawton

In Part 1 you were introduced to the idea of using a computer to predict and plot waveshapes produced by certain standard circuit arrangements. Last time it was for the Resistor-Capacitor series circuit. Now it is the turn of the Capacitor-Resistor series circuit, and the aim of this, Part 2, is fourfold:

1. To evaluate the impedance of the C-R series circuit at various frequencies using a short computer program.
2. To plot the impedance on log scales as a Bode diagram and to discuss the result.
3. To use the computer program IC (Impedance and Complex Number Calculations) to evaluate and plot the impedance.
4. To suggest 'Things to do'.

The concept of impedance, that is, the apparent resistance in an electric circuit to an alternating current flowing in the circuit (Chamber's dictionary), has been discussed by Graham Dixey in his Square One, Part 3 ('Electronics' issue 39, pages 8 – 9).

When the electromotive force (emf) varies sinusoidally, the arithmetic involved in calculating the impedance, current and potential differences is tedious and repetitive. It is this sort of arithmetic that is better done with the aid of a hand calculator, and best done by a computer, especially as the computer can also be used to plot (draw) the results as an oscillograph. It has been assumed that the reader is familiar with the theorem of Pythagoras, tangents of angles and with logarithms. All this can be practised on a hand calculator (note the key P/R Polar/Rectangular, use the values 1, 1 1,10 1,0·1.

The short computer program shown in Listing 3 (PC GW BASIC version) or Listing 4 (BBC Acorn BASIC version) is used to evaluate and plot the impedance of the C-R series circuit for a wide range of frequencies. This program is described in more detail later. To reiterate, program listings are given in both GW BASIC, as used on the IBM PC and compatibles; and BBC BASIC, as used on the Acorn BBC micro, throughout this series. But there is nothing to stop the reader adapting the programs to run on other machines. It is those statements used to actually plot the waveshapes onto the screen that will need to be changed for a different machine. For example where PLOT69,x,y is used to 'set' a single pixel in BBC BASIC, PSET(x,y) is used in GW BASIC. The Acorn computer was used in MODE 4 because it can then be connected directly to a video recorder, and the screen displays recorded.

Figure 4 shows the resultant output of this program as a plot of the impedance. The upper trace is the magnitude, whilst the lower one is the phase. The frequency ranges from 1 r/s up to 100,000 r/s (1E0 up to 1E5). At low frequencies the impedance is both high and capacitive ($X >> R$), while at high frequencies the impedance is constant and resistive ($X << R$). The interesting range is between 1E2 r/s ($X > R$) and 1E4 r/s ($X < R$). Beyond this range of two decades, the impedance ceases to change and becomes resistive only. The associated 'phase angle' changes between −90 and 0 degrees.

The middle frequency (on the log scale) is 1E3 r/s at which the reactance X equals the resistance R. This frequency is equal to the reciprocal of the time constant and is known as the break frequency ωb (lower case omegabee).

At the break frequency (when $\omega = \omega b$), the magnitude of the impedance is $10000 \times 1{\cdot}414\Omega$, whilst the 'phase angle' is −45 degrees. At ten times the break frequency (when $\omega = 10 \times \omega b$) the impedance is $10000 \times 1{\cdot}005$, angle −5·7. This type of plot is known as a 'Bode diagram', and is very useful because it can be constructed from 'asymptotes'. An asymptote is, mathematically, a line that continually approaches a curve but never meets it.

Two asymptotes can be used to approximate the magnitude, and three asymptotes can be used to approximate the 'phase'. The two 'magnitude' asymptotes meet at the break frequency ($\omega b = 1 \div CR$), and the three 'phase' asymptotes are symmetrical about the break frequency and the 'phase angle' of −45 degrees. This is indicated in more detail in Figure 6 where the positions are marked by crosses. These occur because the horizontal axis is the logarithm of the frequency, whilst the vertical axis is the logarithm of the magnitude (×20). The 'phase angle' is plotted directly.

Within the BASIC program these are dealt with in Line 150, where the appropriate horizontal and vertical values (XA, YA) are evaluated.

```
5  REM  CR Listing 1  PC version PJL
10  SCREEN 2 : CLS
20  PRINT "  C-R SERIES CIRCUIT"
30  PRINT "  IMPEDANCE AND FREQUENCY"
40  LOCATE 14,1 : PRINT  "1E0          1E1          ";
50  PRINT "1E2          1E3          1E4          1E5  r/s"
60  LOCATE 22,1 : REM DOWN TO FINISH
70  OS=100 : LINE (0,OS)-(520,OS) : REM ZERO LINE
80  C=.0000001 : R=10000 : WB=1/(C*R) : REM  r/s
90  REM ZMAG=SQR(R^2+X^2)        : REM REACTANCE
100 REM ZPHA=ATN(X/R)            : REM X=1/(W*C)
110 REM  PHASE ANGLE IN 4TH QUADRANT
120  FOR P=0 TO 5 STEP .1        : W=10^P
130 ZMAG=R*SQR(1^2+(W*C*R)^2)*1/(W*C*R)
140 ZPHA=(ATN(W*C*R/1)-1.57)*57.3
150 XA=LOG(W)/2.3 : YA=20*LOG(ZMAG)/2.3 : REM dBs
160 PSET(XA*104,OS-YA*.5)
170 PSET(XA*104,OS-ZPHA*.5)
180  NEXT P  : REM L-R CIRCUIT? 1 & 1000
```

Listing 3. The Capacitor-Resistor plotting program written in GW BASIC.

```
5  REM  CR Listing 2  BBC Acorn version PJL
10  MODE 4
20  PRINT "  C-R SERIES CIRCUIT"
30  PRINT "  IMPEDANCE AND FREQUENCY"
40  PRINT TAB(0,26); "1E0          1E1          ";
50  PRINT "1E2          1E3          1E4          1E5  r/s"
60  PRINT TAB(0,1)  : REM DOWN TO FINISH
70  OS=200 : MOVE 0,OS : DRAW 1000,OS : REM ZERO LINE
80  C=1E-7 : R=1E4 : WB=1/(C*R) : REM  r/s
90  REM ZMAG=SQR(R^2+X^2)        : REM REACTANCE
100 REM ZPHA=ATN(X/R)            : REM X=1/(W*C)
110 REM  PHASE ANGLE IN 4TH QUADRANT
120  FOR P=0 TO 5 STEP 0.1  :  W=10^P
130 ZMAG=R*SQR(1^2+(W*C*R)^2)*1/(W*C*R)
140 ZPHA=(ATN(W*C*R/1)-1.57)*57.3
150 XA=LOG(W)/2.3 : YA=20*LOG(ZMAG)/2.3 : REM dBs
160 PLOT69,XA*200,YA*1+OS
170 PLOT69,XA*200,ZPHA*1+OS
180  NEXT P  : REM L-R CIRCUIT? 1 & 1E3
```

Listing 4. The program in BBC BASIC form.

Lines 90, 100 and 110 contain the usual formulae for impedance and phase. Remember that the reactance X ($X = 1 \div WC$) changes with frequency, whilst the resistance R is constant. The important feature is the ratio of the reactance to the resistance ($X \div R$). At one particular frequency the reactance equals the resistance ($X \div R = 1$), and it is this frequency that is known as the 'break frequency' ωb (lower case omega-bee). Note that $\omega b = 1 \div (C \times R)$ that is, ωb equals $1 \div \tau$ (one over tau), where τ is the time constant. In order to predict the 'phase' correctly (in the 4th quadrant), the capacitive reactance is linked with an operator of -1, thus 'ATN (−X/R)' could be used in line 100. Note that the capacitive reactance is not negative.

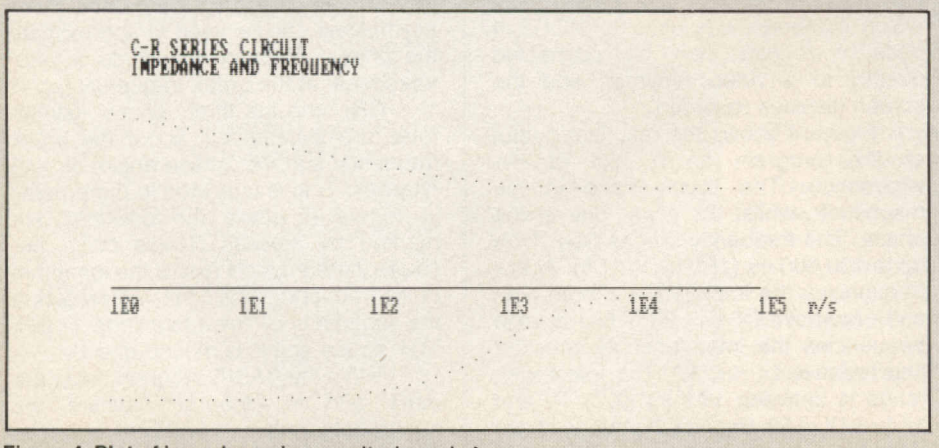


Figure 4. Plot of impedance in magnitude and phase.

Lines 130 and 140 contain a rearrangement of the usual formulae. This is meant to emphasise the two terms '*SQR(1 ↑ 2 + (W*C*R) ↑ 2)' and '*1/(W*C*R)'. These two terms appear in many other expressions (see Appendix 1). The angle of −1·57 rads (−90°) is related to the term *1/(W*C*R).

Both sets of formulae should be evaluated (in long hand) at a frequency equal to the break frequency. The results should be 'ZMAG = 1E4 * 1·414' ohms, ZPHA = −45 degrees. This evaluation should be used to check the results from the program at ω = 1000 r/s (the break frequency). Other interesting frequencies are 100 r/s and 10000 r/s.

Another advantage of the Bode

diagram is that the current is easy to predict. If the supply voltage is 1sin(ωt), then the current is predicted by the negative of the impedance plots:

By Ohm's law:

$i = e \div z$

using logs:

$\log(i) = \log(e) - \log(z)$

as $e = 1$: $\log(i) = 0 - \log(z)$

Similarly the potential difference (v) across the resistor is:

By Ohm's law:

$v = R \times i$

using logs:

$\log(v) = \log(R) + \log(i)$

This yields the frequency response of the high pass filter (v÷e). Note that the plot is 20 times the log.

When sine waves are considered, the calculations involve the frequency and two numbers, for example resistance and reactance. The subsequent calculations are repetitive and very tedious. Figure 5 shows part of the input and output to a computer program called 'IC' (see Appendix 2), and Figure 6 shows the resultant Bode diagram. The input to program IC can be amended to include an emf and to calculate the current and potential differences. These results can be superimposed on the Bode diagram to illustrate the high pass filter. The program also contains sets of harmonics which can be related to the Bode diagram, but that is another topic.

Things to Do

Construct the C-R circuit and apply an emf of 1 × sin(1000 × t).

Measure the volt drop across the resistor using an oscilloscope and calculate the current.

Hence calculate the impedance in magnitude and phase.

Compare these results with the predictions and decide whether the formulae

Z = SQR(R ↑ 2+X↑2),

where X = 1 ÷ (ω × C), is valid.

Repeat at frequencies of 100 and 10,000, or at 500, 250, 125 and 2000, 4000, 8000.

Make a video recording of the experiment (four minutes) and of the program.

If the resistor is reduced to 1E3 and the capacitor increased to 1E6, the break frequency is still 1E3 r/s.

The impedance changes by the factor 0·1 whilst the current changes by the factor 10. If these factors are expressed in logarithmic units using the expression 20 × LOG (the change in level) the resultant values are −20 and +20 respectively. In popular jargon these values are 20dBs down and 20dBs up respectively.

The programs can be altered so that they represent the Inductor-Resistor series circuit (use L = 1 and R = 1000). Both sets of formulae should be evaluated (in longhand) at three classical

```
                IMPEDANCE & COMPLEX NUMBER CALCULATIONS.
                        Frequency =  1.59159E+02 Hz
                    W = 2*3.142*F =  1.00002E+03 rad/s
                PT=1/F =   6.283/W =  6.28302E-03 s

  INPUTS                                RESULTS
  ======                                =======
VARIABLE                        RESISTANCE  REACTANCE     IMPEDANCE    PHASE
   MNEMONIC
     VALUE(S)                   A*SIN(W*T)+B*COS(W*T)  =  M*SIN(W*T+P)
     EQUATION
VAR M VALUE(S) EQUATION         F = 1.59159E+02 Hz        W = 1.00002E+03 r/s


 Z2 R 1.0000E+04                1.00E+04 +J 0.00E+00     1.00E+04 +P   0.0   Z2
 Z0 C 0.0000E+00, 1.0000E-07    0.00E+00 -J 1.00E+04     1.00E+04 -P  90.0   Z0
 Z1 = Z2 + Z0                   1.00E+04 -J 1.00E+04     1.41E+04 -P  45.0   Z1
```

Figure 5. Input and output of computer program 'IC'.

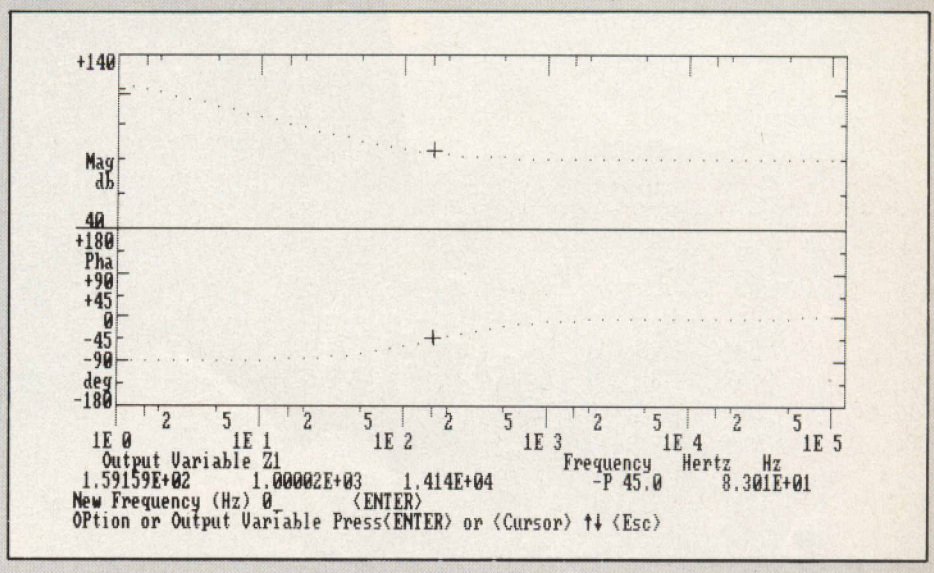


Figure 6. Bode diagram from computer program 'IC'.

values of frequency as follows:

1) ω = 1 ÷ (L ÷ R) × 1 (ωb)

2) ω = 1 ÷ (L ÷ R) × 10 (ωb × 10)

3) ω = 1 ÷ (L ÷ R) ÷ 10 (ωb ÷ 10)

These results are directly related to the usual Bode diagram theory.

Summary

In this part of the series, the impedance of the C-R series circuit has been evaluated by a short computer program, and the subsequent Bode diagram and its asymptotes has been discussed. Computer program IC has been used. Things to do have been suggested. As the idea of break frequencies is so useful, and indeed so often used, it is worth studying the subject in a diligent manner. Remember though that ωb (lower case omegabee) equals one over tau (1/τ).

Appendix 1

Lines 130 and 140 of the program contain a very useful rearrangement of the usual electrical formulae. This deliberate rearrangement produces terms containing frequency multiplied by time constant (omega × tau, or ω × τ). These two terms, in the program, are '✳SQR (1 ↑ 2 + (ωτ) ↑ 2)' and '✳1/ωτ', where τ equals C✳R. The asymptotes related to these terms are easy to sketch, along with the constant R.

An identical term can be produced from the Inductor-Resistor series circuit. The impedance is $SQR(R^2+(W \times L)^2)$, hence:

'ZMAG = R ✳ SQR(1 ↑ 2+(W✳L/R) ↑ 2)'

'ZPHA = ATN((W✳L/R)/1)'

This time the term is ✳SQR(1 ↑ 2 + (ωτ) ↑ 2), as well as the constant R.

Other combinations of capacitors and resistors produce similar expressions for impedance, current and potential differences. The oscilloscope input impedance and probe are useful circuits to study. The Inductor-Resistor-Capacitor series circuit is very interesting, but that is another topic. Part 3 will introduce the inductor into the system, while predicting waveshapes for the Resistor-Inductor circuit.

Appendix 2

Personal Computer Program 'IC', Impedance and Complex Number Calculations, by Barry Barker and Philip Lawton. This program provides tabulated inputs, calculations and results; plus the three classical graphs: Sinusoidal waveforms of all the signals; Bode diagrams of the frequency response; Harmonic summation of 0 to 16 harmonics. It can be used to model passive circuits and to evaluate transfer functions at any frequency. With the advent of a video display which is large and flat, the reality of 'Electronic Chalk and Talk' will be widely available. This program is ready.

Further details are available, telephone 0533 413889 (Mondays 2-3pm or 7-8pm).

2ND Time Around

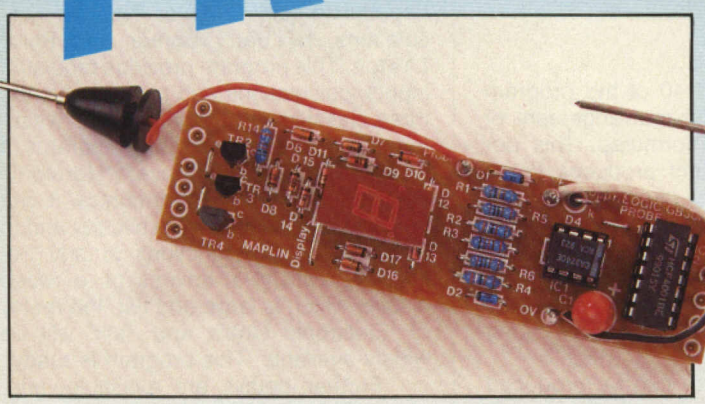
Many projects from Maplin's range of kits have proved to be very popular over the years, but some of the older ones need updating and improving to meet the higher modern standards expected of them, and to use the current technology now available. This newly developed design supersedes the original and has a new probe and case design for easier construction.

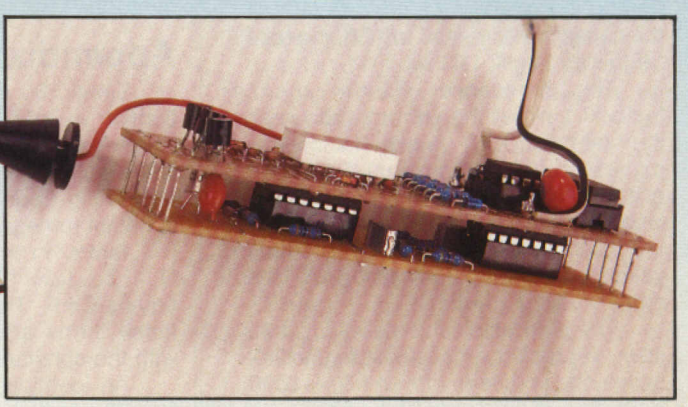
CMOS LOGIC PROBE

FEATURES

★ Designed specifically for high CMOS levels ★ High, low, floating and pulse indication ★ Instantly recognisable logic states ★ Over volts protection ★ Low current consumption

by Graeme Durant





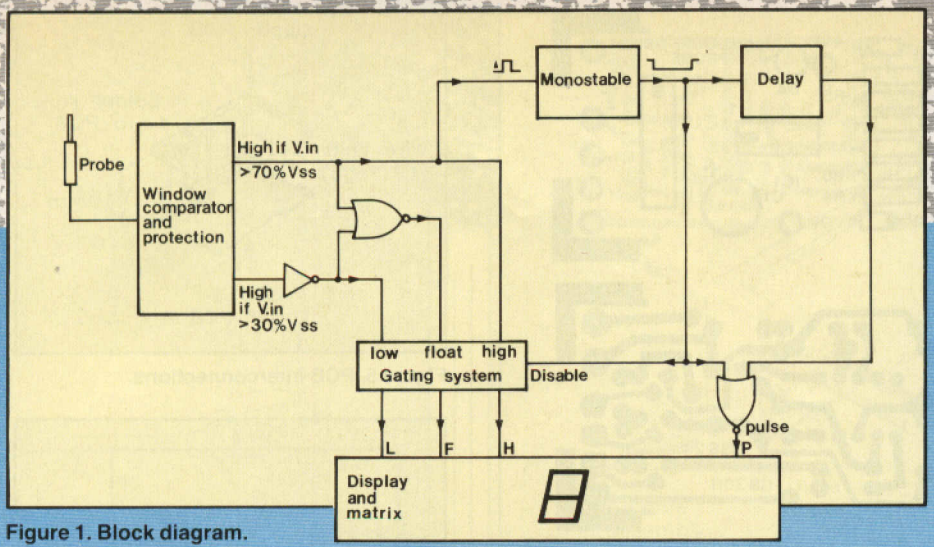


Figure 1. Block diagram.

Over the years, countless designs have appeared in the electronics press for logic probes; ranging from very simple High/Low indicators, to complex pulse stretching probes. The logic probe described here, has a number of features found only on the more complex probes, and as such, lies somewhere between these two extremes. Thus it is perfectly suited to day to day fault diagnosis.

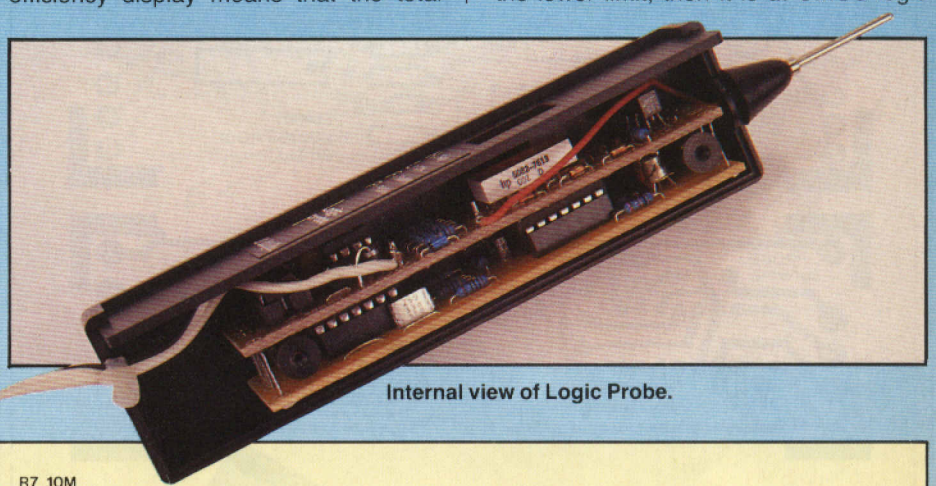
As well as detecting High and Low logic states, open circuit (floating input) and pulsing inputs are displayed. Pulse trains from around 1Hz are detected as a pulsing input, the upper limit is above that attainable in most common CMOS logic (not low voltage type).

The main difference between this logic probe and all others is that the output is shown on a seven segment LED display, as a letter of the alphabet; H for High; L for Low; F for Floating; P for Pulsing. In this way, the logic state is instantly recognisable and totally unambiguous. The use of a special high efficiency display means that the total current consumption at a supply voltage of 15V is only 15mA — quite suited to battery operated circuits. In addition, the probe is protected against over-voltage inputs, and reversed supply.

Block Diagram

The input from the probe goes via a protection network to a window comparator, with switching levels of 70% V_{ss} and 30% V_{ss}; these are the standard CMOS limits. If the upper limit is exceeded, then the probe input is CMOS logic high. Thus, the upper output goes on to the display circuitry for HIGH indication.

If the probe input does not exceed the lower limit, then it is at CMOS logic



Internal view of Logic Probe.

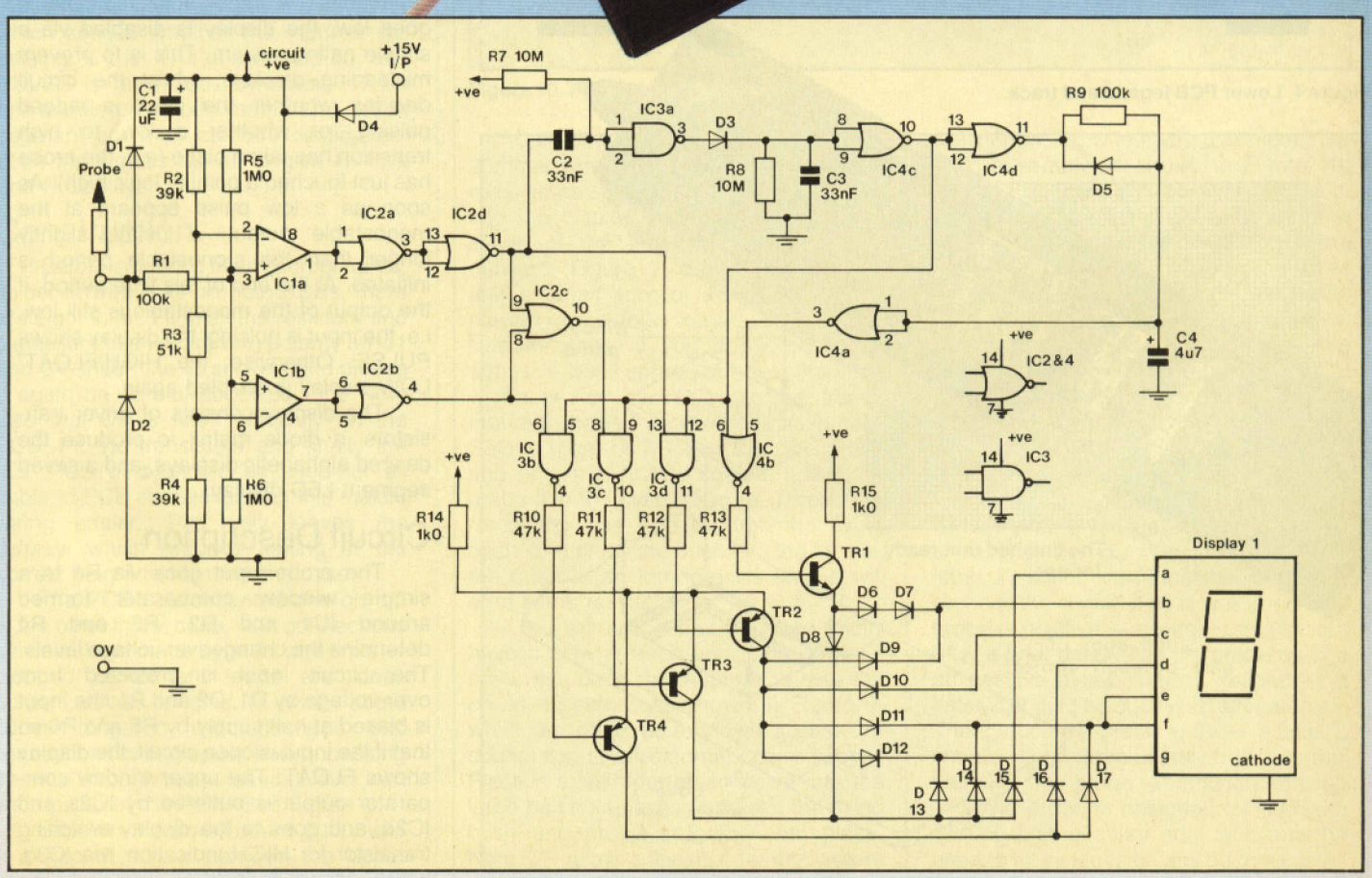


Figure 2. Circuit diagram.

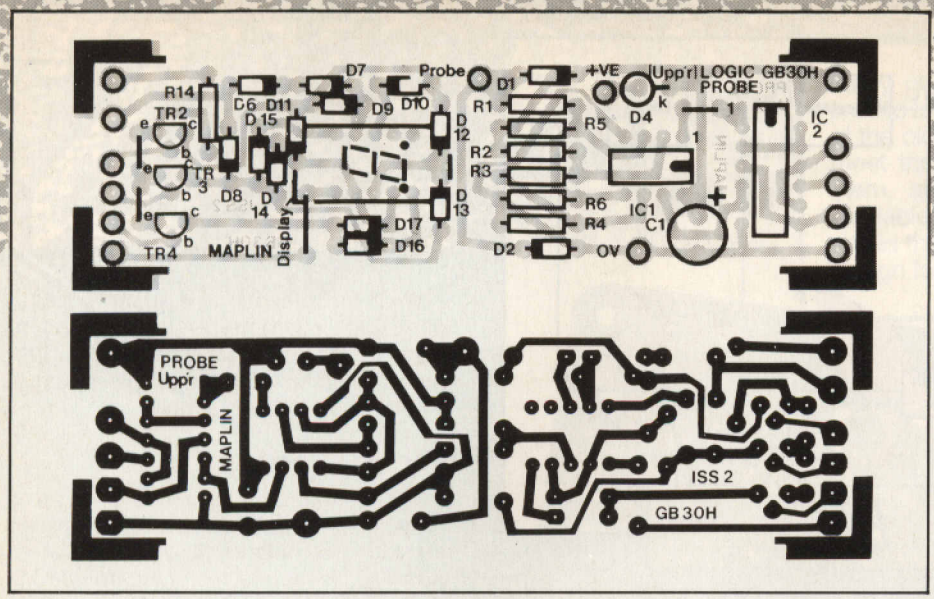


Figure 3. Upper PCB legend and track.

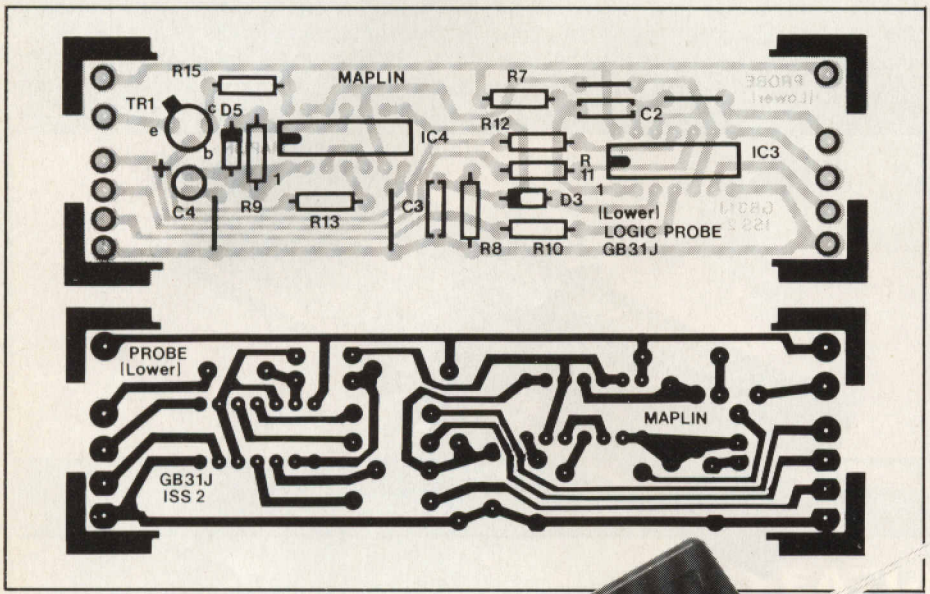


Figure 4. Lower PCB legend and track.

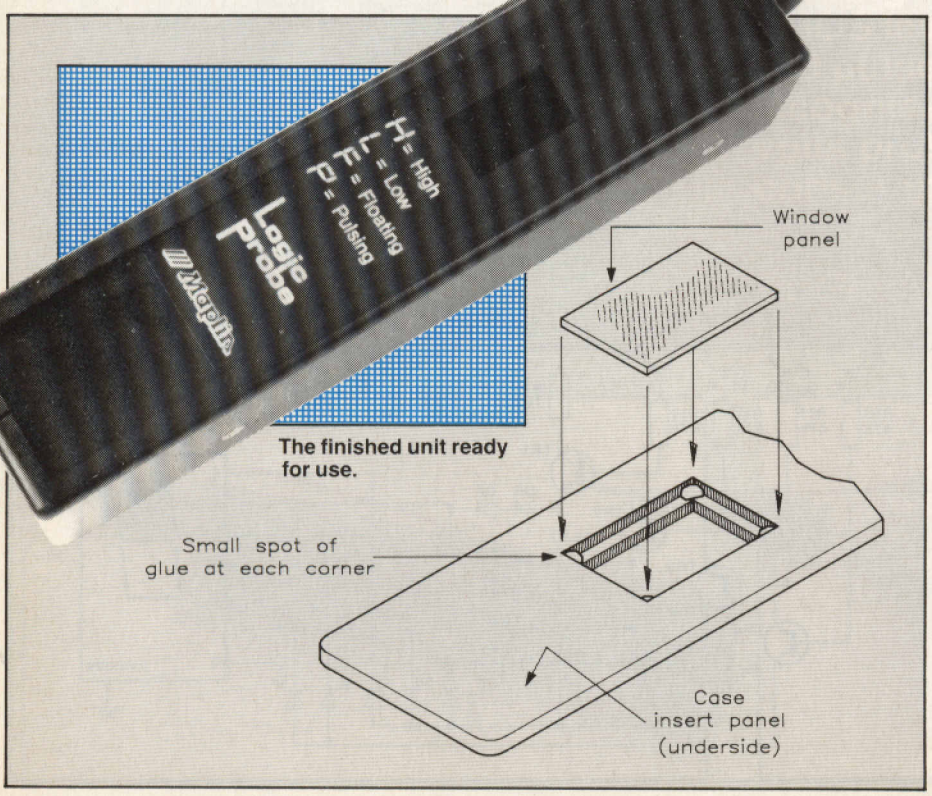


Figure 7. Mounting the window panel.

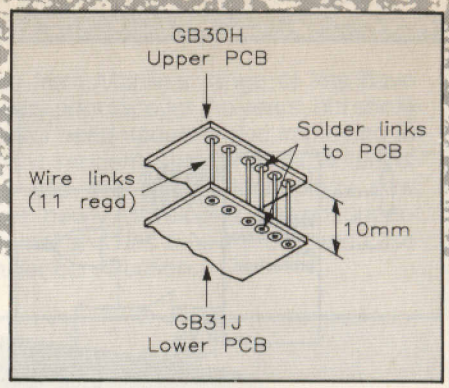


Figure 5. PCB interconnections.

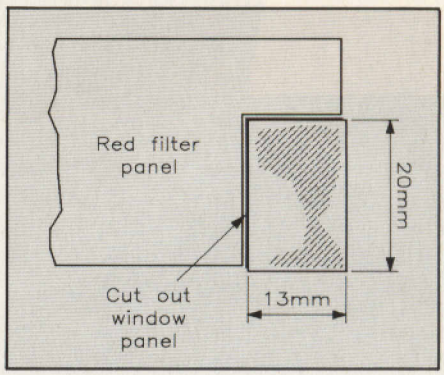


Figure 6. Display window panel.

low. The output of the lower comparator is inverted to give a high level at the display circuitry for LOW indication. If the probe input is between logic levels, then the upper comparator will be low and the lower comparator high. These two outputs are fed to a NOR gate, which gives a high level to the display circuitry on FLOAT.

The HIGH indication also drives a retriggerable monostable, to produce a continuous low output. If this monostable goes low, the display is disabled via a simple gating system. This is to prevent misleading displays, whilst the circuit decides whether the input is indeed pulsing, or whether a low to high transition has taken place (e.g. the probe has just touched a point at logic high). As soon as a low pulse appears at the monostable output, a delay, slightly longer than the monostable period is initiated. At the end of this time period, if the output of the monostable is still low, i.e. the input is pulsing, the display shows PULSE. Otherwise, the HIGH/FLOAT/LOW display is enabled again.

The display consists of driver transistors, a diode matrix to produce the desired alphabetic displays, and a seven segment LED display.

Circuit Description

The probe input goes via R1 to a simple window comparator formed around IC1 and R2, R3 and R4 determine the changeover voltage levels. The circuit input is protected from over-voltage by D1, D2 and R1; the input is biased at half supply by R5 and R6 so that if the input is open circuit, the display shows FLOAT. The upper window comparator output is buffered by IC2a and IC2d, and goes to the display switching transistor for HIGH indication, via IC3d, which allows the HIGH display to be disabled.

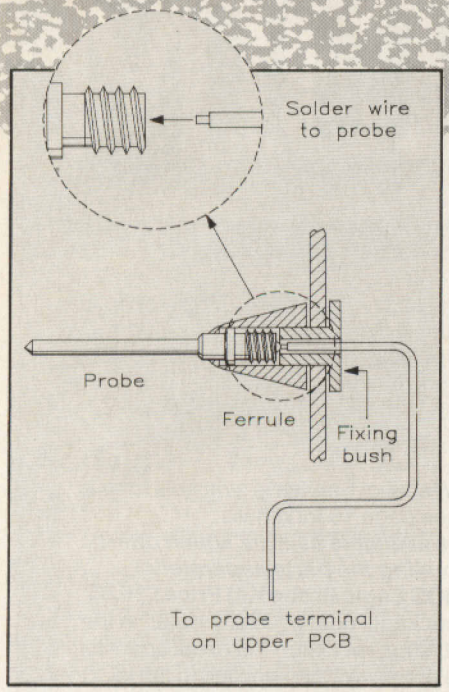


Figure 8. Probe assembly.

The low and float displays are similarly connected, using IC2b and IC3b for LOW, and IC2c and IC3c for FLOAT.

A simple CMOS monostable wired around IC3a and IC4c, and having a period of around 0·5 seconds senses a pulsing input. Its output, which is normally high, disables the HIGH/FLOAT/LOW display, and starts a delay, formed around C4 and R9, which is a little over the monostable period. The output of the RC delay is inverted and fed to IC4b, which senses whether the input is still pulsing. If it is, TR1 is switched on, and PULSE is displayed. Otherwise TR1/4 are enabled. A diode matrix and seven segment common cathode display decode the signals, so as to give H, F, L and P displays.

Construction

Before soldering in any components, solder in wire links on both PCBs, there are eight in all. Fit in all the resistors and capacitors taking care with polarity on C1 and C4. Insert the IC sockets and diodes – again be careful about polarity. Note also that D4 is fitted vertically on the PCB. Fit the transistors and finally the ICs. PCB pins should be used for all cable to PCB connections as this makes wiring easier. This only leaves the display, which requires setting at the correct height to fit inside the case.

The PCBs are mounted one on top of the other in the case, with connections between both made by solid wire links — cropped component leads are ideal. Solder eleven lengths of wire, about 20mm long, to the underside end connections of the upper board, passing the wire through the holes until level with the topside of the PCB. See Figure 5.

Slide on the lower board until there is a gap of 10mm between the upper board and the lower PCB, solder the wires to the bottom board and crop.

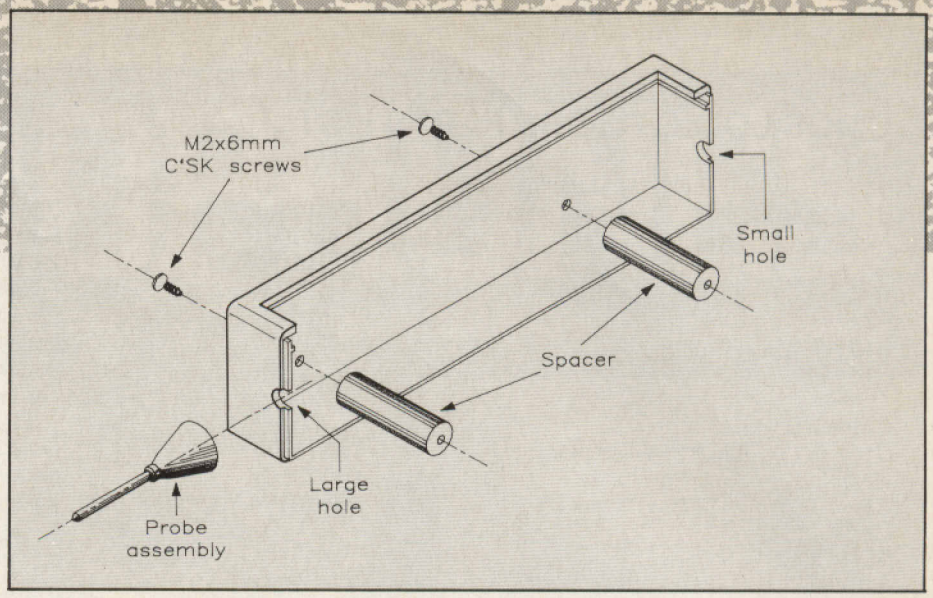


Figure 9. Case assembly.

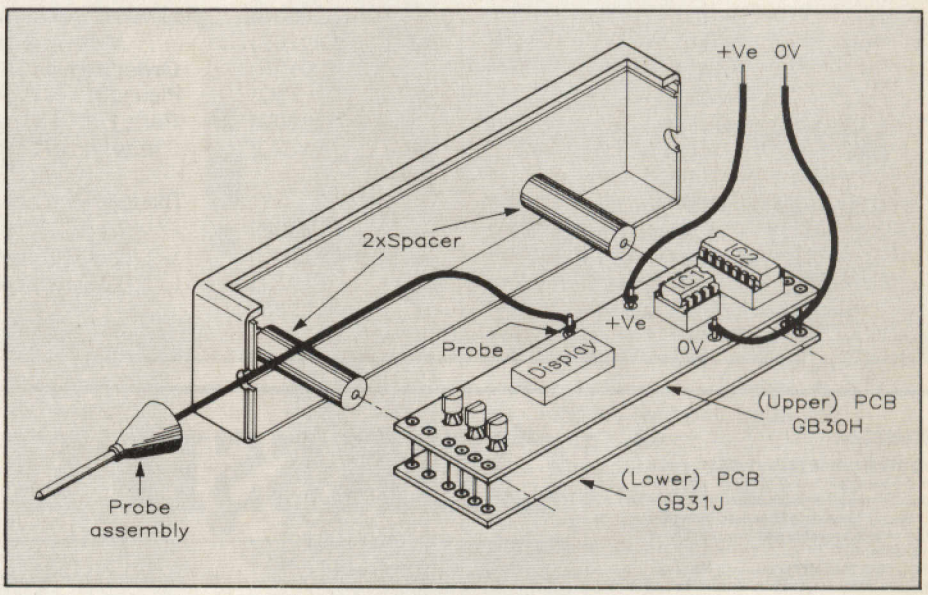


Figure 10. PCB mounting.

Carefully cut out a rectangular 20mm x 13mm section from the sheet of red filter as shown in Figure 6, and place into the display window recess on the inside of the insert panel, matt side outward. Figure 7 shows the method, and a *small* spot of adhesive can be placed in the four corners, to hold the filter in place. If you apply too much adhesive it will spread out over the filter, which is not desirable, so be frugal. Figure 8 shows the new probe assembly. Solder 10cm of 7/0·2 wire to the probe end and once it has cooled, insert the probe into the plastic ferrule. Thread the remaining wire end through the fixing bush, and press the bush into the ferrule; the bush is an interference fit and will offer some resistance.

You will notice that the case shells have a hole at each end. One of these holes has been made larger to take the probe assembly, as shown in Figure 9, while the other hole allows access for connection to an external power supply. Place a small spot of adhesive into the large half hole section and slot the fixing bush and probe assembly into place. Note — allow adhesive to dry before assembling both case halves together!

Fit both spacers as shown, using an M2 x 6mm screw in each, and mount the PCB assembly as shown in Figure 10; the two spacers will hold the PCBs in position. Solder the probe wire onto the upper board terminal and two wires to the +Ve and 0V terminals. The power wires should be secured using a cable-tie. Croc' clips should be fitted to these wires. Finally, fit the insert panel with the window filter positioned above the PCB display, and fix the remaining case shell with two M2 x 6mm screws.

Testing and Use

Power the circuit up with a typical CMOS supply voltage. After around half a second, the display should show a letter F. If not, disconnect quickly, and recheck the circuit. If all is well, touch the probe to positive — a letter H should light after a brief delay. Tap the probe on and off positive a few times a second — a letter P should be displayed after a delay. Then, touch the probe to 0V — a letter L should light immediately. If all this happens, the probe is working perfectly.

The probe is designed for use with CMOS logic circuitry *only*, and may be used to trace faults on any such logic. All that remains now is to find a suitable circuit to test!

CMOS LOGIC PROBE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,9	100k	2	(M100K)
R2,4	39k	2	(M39K)
R3	51k	1	(M51K)
R5,6	1M	2	(M1M)
R7,8	10M	2	(M10M)
R10–13	47k	4	(M47K)
R14,15	1k	2	(M1K)
CAPACITORS			
C1	22μF 25V Tantalum	1	(WW73Q)
C2,3	33nF Poly Layer	2	(WW35Q)
C4	4μ7F 35V Tantalum	1	(WW65V)
SEMICONDUCTORS			
IC1	CA3240	1	(WQ21X)
IC2,4	4001BE	2	(QX01B)
IC3	4011BE	1	(QX05F)
TR1	BC107	1	(QB31J)
TR2–4	BC557	3	(QQ16S)
D1,2	BAR28	2	(QQ13P)
D4	1N4001	1	(QL73Q)
D3,5–17	1N4148	14	(QL80B)
DY1	Low Current Display	1	(QY54J)
MISCELLANEOUS			
	Probe Upper PCB	1	(GB30H)
	Probe Lower PCB	1	(GB31J)
	8-pin DIL Skt	1	(BL17T)
	14-pin DIL Skt	3	(BL18U)
	Black Croc Clip	1	(FK34M)
	Red Croc Clip	1	(FM37S)
	Zip Wire	1m	(XR39N)
	Filter Red	1	(FR34M)
	Pin 2141	1Pkt	(FL21X)
	Logic Probe Case	1	(JX57M)
	Logic Probe Label	1	(JX58N)
	Tie-Wrap 100	1	(BF91Y)
	7/0·2 Wire Black	1Pkt	(BL00A)
	Double Bubble Sachet	1	(FL45Y)
	Instruction Leaflet	1	(XK91Y)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see page 15 for details.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LK13P (CMOS Logic Probe Kit) Price £16.95

Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately:

Logic Probe Case **Order As JX57M Price £1.45**

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WANTED: Philips reel to reel tape recorder Model 4520. (081) 800 7636.

WANTED: MANUAL FOR APRICOT COMPUTER (dual 3½" disc model). £5 offered for photocopy or loan. Phone B. Jones (04024) 37772, Hornchurch, Essex.

WANTED: V9938 graphics procesor for Maplin video frame store. Also information if available. Tel: (0344) 420393 evenings or weekends.

WANTED: Student requires any information on a Datacomms Modem 2426, but particularly service information. Please contact Mr K. D. Kimber, 27 Walton Close, Worthing, West Sussex. BN13 2BJ. Tel: (0903) 690770.

WANTED: Service Manual/Circuit Diagram and/or Handbook for PHILIPS PM 3110/03 Oscilloscope. Any costs met. Tel: Dave on Derby (0332) 774963.

WANTED: EPROM programmer, PC type RS232 interface, with software. PCB drafting software, cheap Oscilloscope. Mel Saunders, 7 Drumcliff Road, Leicester, LE5 2LH. Tel: (0533) 419742.

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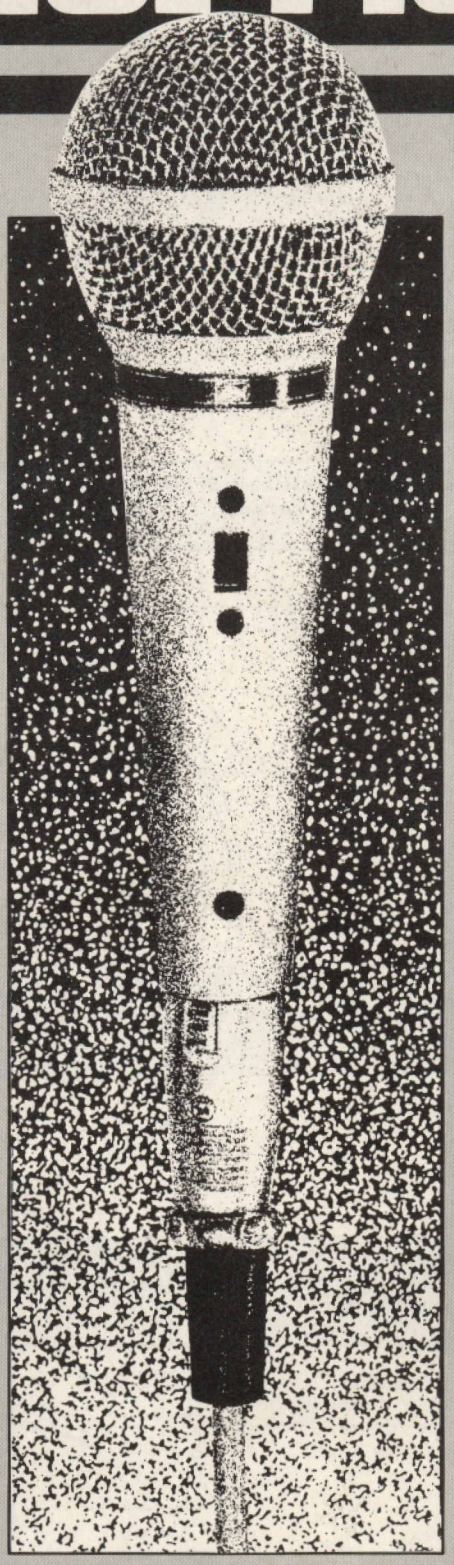
MICROPHONES

by J.M. Woodgate

B.Sc.(Eng.), C.Eng., M.I.E.E., M.A.E.S., F.Inst.S.C.E.



Memoir

My first introduction to microphones was at about the age of ten, and the microphone in question was made by Tannoy for the intercom associated with the Army No. 19 Set transceiver used in tanks in the Second World War. Many thousands of these sets were made, and I recall that the control boxes that I acquired (one shilling (5p) each, I believe) had Russian markings applied over the English. These markings were luminous and I have no doubt that they contained enough radium for the units to be now classed as nuclear waste. There were piles of them in the surplus stores!

Inside Story

The microphone was a massive beast – it had to be, to be soldier-proof under battle conditions. It was housed in a thick aluminium case, and the head had (purely decorative?) fins like a heat sink for a 100W amplifier. Equipped with a handle about 200mm long, it would have formed a handy weapon in itself! Internally, the construction was very intricate, with a corrugated aluminium diaphragm fitted with about twelve nickel-plated studs, each one of which formed one electrode in a 'cell' containing activated carbon granules, a very pure form of charcoal. The other electrode was common to all cells, and formed a backplate. Such a device would cost hundreds of pounds today, because almost every part was machined from solid; there were no cheap plastic mouldings in those days, although the case was made from aluminium castings, and the front-plate of the microphone itself was a heavy thermosetting moulding. There was a moulded rubber mouthpiece, which you clamped over your mouth to try to exclude some of the machinery noise inside the tank.

Carbon Microphone

This was, of course, a carbon microphone, which you will only find today in old-style telephones. My interest was mainly in the associated headphones, for use with a crystal set, doomed to failure because the headphones were low-impedance and the idea of a matching transformer was a bit too advanced. I had them, taken off old loudspeakers, but nobody to explain how to use them (no Maplin Magazine in those days, either!). But the microphone held out exotic promise. My father told me he had seen a crystal set driving a loudspeaker quite loudly, using a 'box of tricks' powered by a cycle-lamp battery. He remembered that the box contained a microphone, but no more details. What he was describing was the 'microphonic amplifier' which I mentioned in 'Loudspeakers – the first 111 years' Part 1, in Issue 28 of 'Electronics'. In point of fact, I guessed that you had to connect the earphone diaphragm mechanically to the microphone diaphragm, but I certainly didn't have the mechanical skills, nor the tools, to do it.

Modern Microphones

Nowadays, we really only have two types of microphone to consider, the electret and the moving-coil ('dynamic'). Recording engineers also use ribbon and (externally-polarized) capacitor microphones, and the latter are also used for electro-acoustic measurements, but they are all rather expensive and unlikely to feature in the home laboratory. Ribbon microphones, with the exception of the prized Coles (formerly STC) 'lip-ribbon', tend to suffer from lack of ribbon if swallowed by pop-artist or DJ. The lip-ribbon is another design intended to be clamped to the mouth, and was developed for broadcast sports commentators many years ago. It has not been displaced by a newer design, presumably because it is so nearly perfect.

Microphone Characteristics and Specifications

Four main characteristics define most of the information we need to know about a microphone, and should be included in all manufacturers' specifications. These are:

– Sensitivity and rated load impedance, which are partially interdependent, and

– Frequency response and directional response, which are also partially interdependent.

Sensitivity

If we were all physicists, and were quite happy with sensitivity (actually efficiency in this case) defined as electrical power output divided by sound power input, the value would be independent of the load impedance, but we are not all physicists (thank goodness), and sensitivity is defined as the voltage output produced by a given sound pressure input. Both the voltage and the sound pressure may be expressed as levels in decibels. We need to know the sensitivity so as to provide enough, but not too much, gain in the

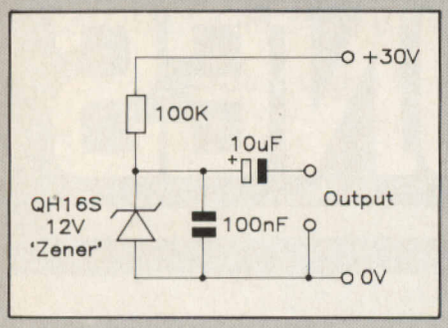


Figure 1. Simple white noise generator. The 100nF capacitor prevents radio pick-up and limits out-of-band noise. This circuit will *not* work with true Zener diodes, i.e. those with breakdown voltage less than 6·8V.

following amplifier. But the voltage output can be changed by including a transformer, either in the microphone case, or in the system somewhere before the amplifier input (YX84F, for example), and this also changes the required load impedance.

It is not practicable for most people to measure the sensitivity of a microphone, although if you have an audio voltmeter, a sound level meter and a source of sine waves or white noise (such as the simple circuit in Figure 1, which can be connected to a high impedance input of a preamplifier and thence to a final amplifier), you can use the arrangement in Figure 2 to make an approximate measurement in the open air. This arrangement eliminates errors due to ground reflection, and gives a value 6dB higher than the standard free-field measurement, for which you need an anechoic room. Normally, you have to rely on the manufacturer's specification, but many manufacturers make a complete hash of this, because the information is collected and sent to the printer, and proof-read, by the Sales Department, who wouldn't know a decibel from a decoherer. With sine-wave signals, you can measure the sound pressure level and the microphone output voltage on the meters at a series of frequencies, and thus deduce the frequency response of the microphone, as well as its sensitivity. A-weighting (or B or C weighting) in the sound level meter has no effect (except perhaps to reduce accuracy at extreme

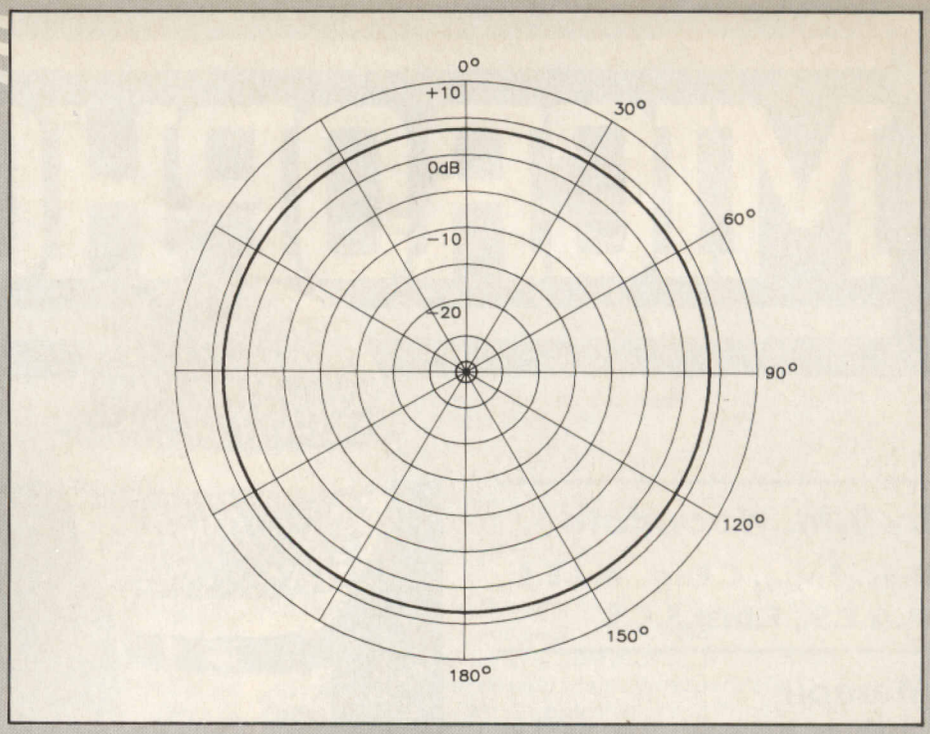


Figure 4a. Horizontal directional response of an omnidirectional microphone with its axis vertical.

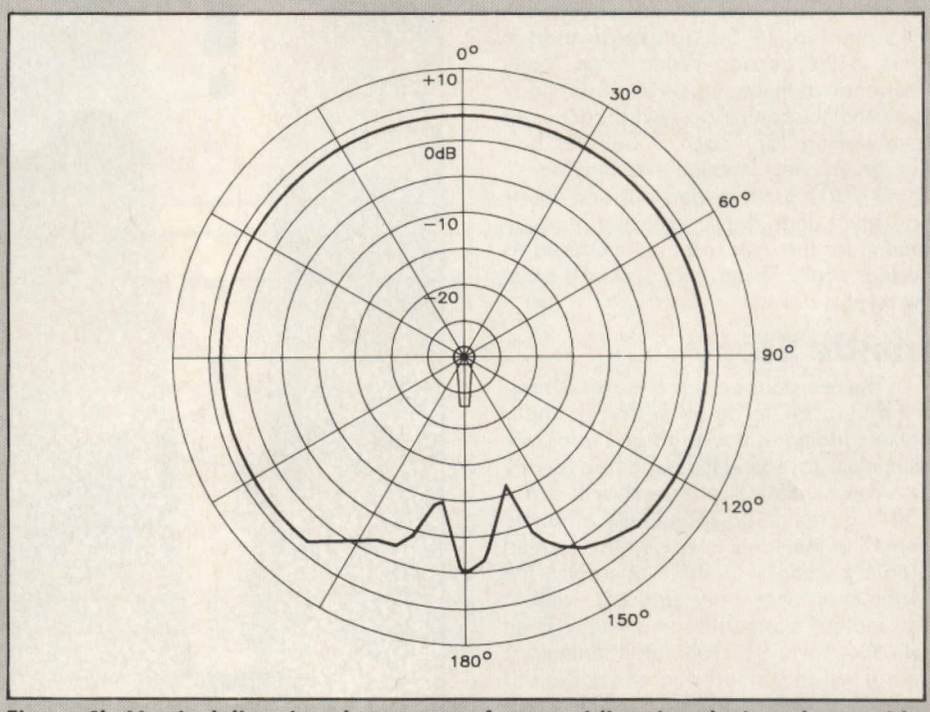


Figure 4b. Vertical directional response of an omnidirectional microphone with its axis vertical. At high frequencies, the disturbance due to the handle may be much greater.

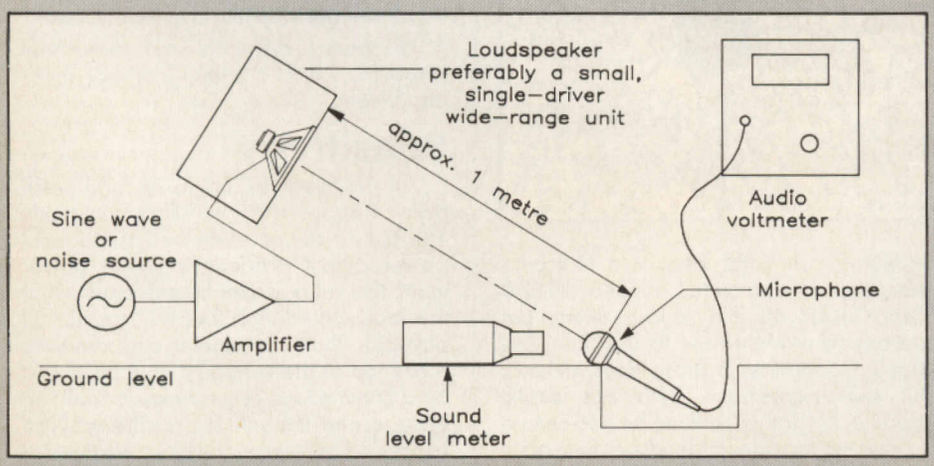


Figure 2. Arrangement for measuring microphone sensitivity and frequency response in the open air.

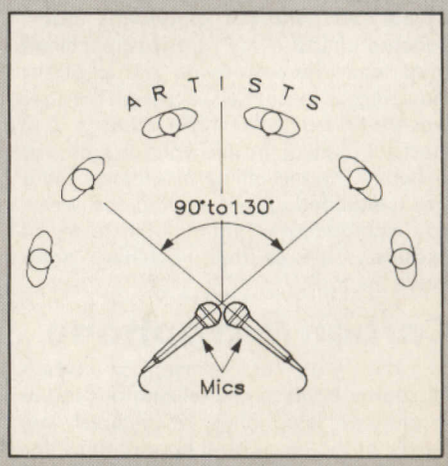


Figure 3. Plan view of a 'crossed-cardioid' set-up for recording.

frequencies). White noise gives you an average sensitivity figure over the audio band, and for this method the sound level meter should be set at 'FLAT' or 'C-weighting'.

Rated Load Impedance

It should be clearly understood that the internal impedance of the microphone itself is quite irrelevant; we need to know, and the manufacturer will, if he has any sense, specify, the load impedance with which the microphone works best. Typically, this is five times the actual internal impedance, so the 'maximum power theorem' ("For maximum power transfer, source resistance equals load resistance and source reactance plus load reactance equals zero") bites the dust yet again as a useful design criterion.

There isn't any way of measuring the correct value of load impedance; you either use the manufacturer's specified value or you guess. For example, most electret microphones require a 1kΩ load, and most modern dynamic microphones also require this value. Generally, 1kΩ will suit older dynamic microphones, designed for load impedances between 200Ω and 600Ω as well, but the much older 50Ω microphones, such as the STC 4021 'ball and biscuit', are not sufficiently sensitive to work well with 1kΩ, and do need a 200Ω to 250Ω load, with the following amplifier optimised for noise performance under these conditions.

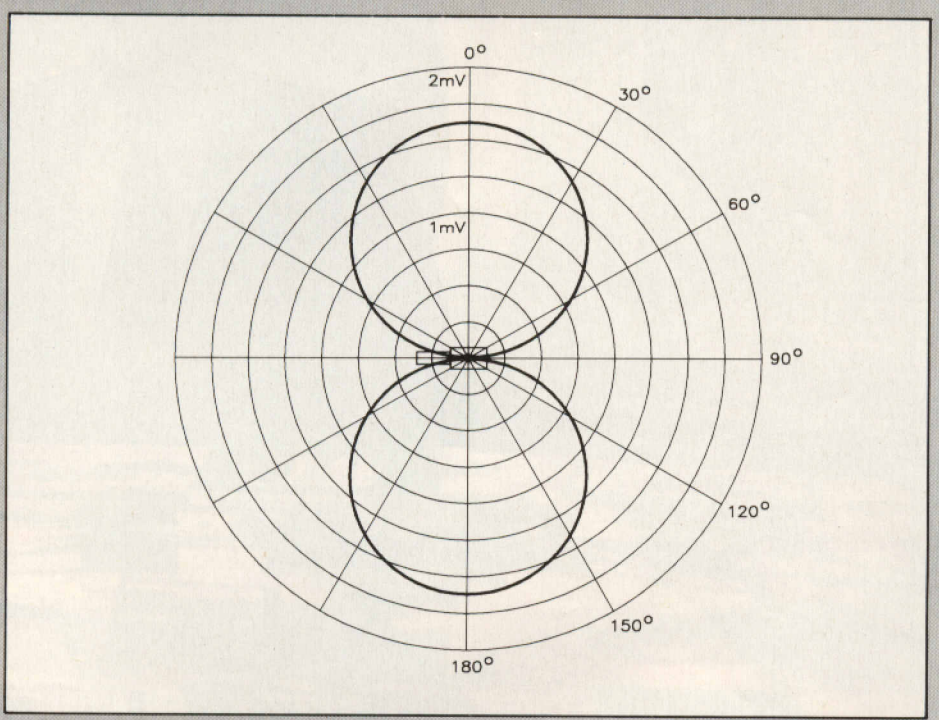


Figure 5a. Directional response of a velocity (e.g. bidirectional ribbon) microphone: linear output voltage scale. The directional response consists of two circles.

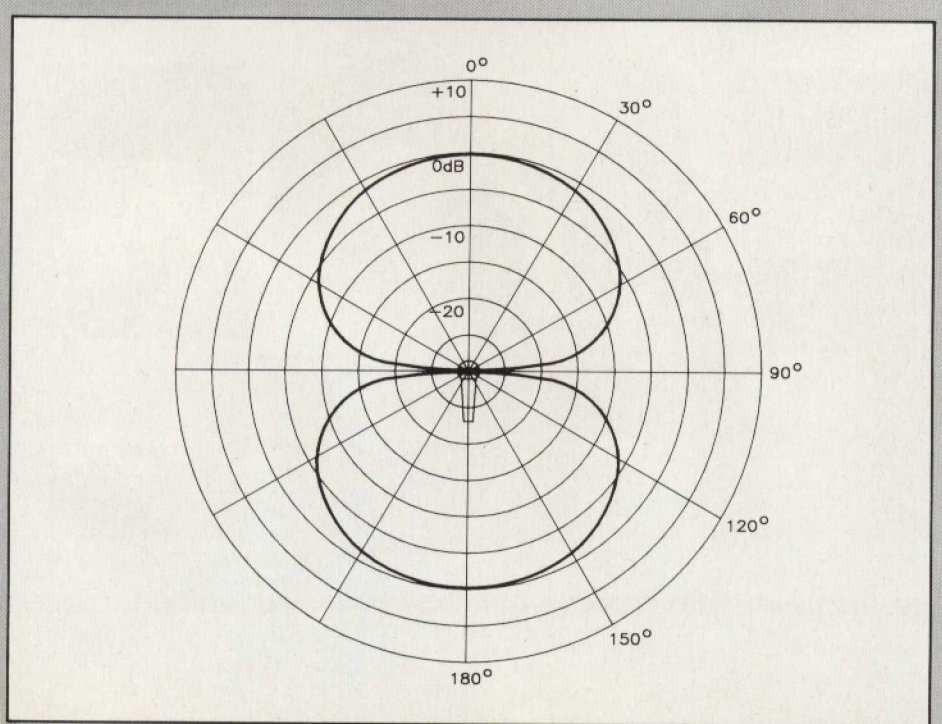


Figure 5b. Directional response of a velocity microphone: output presented on a decibel scale.

Frequency Response

There is far too much attention paid to this characteristic, not only for microphones but for everything else as well. It seems that nothing less than ±0·01dB from DC to light is good enough! This is simply not true: good results can be obtained from a balanced frequency response with no sharp dips or peaks, even if the bandwidth is quite narrow. It has been suggested that a balanced frequency response is one where the product of the lower −3dB frequency in hertz and the upper −3dB frequency in kilohertz is 400. This obviously works for 20Hz and 20kHz, and seems to be reasonably reliable up to 40Hz and 10kHz, but then admits what are clearly unsatisfactory upper limits, e.g. 200Hz and 2kHz. The telephone system limits are 300Hz and 3·4kHz, giving a product of 1020, which also works reasonably for 200Hz and 5·1kHz, representative of a portable TV or radio. I have invented a new (?) empirical formula (remember you read it first in the Maplin Magazine!), which is:

$$f_b \times \sqrt{(f_t)^3} = 60 \times 10^6$$

where f_b is the bass −3dB frequency and f_t is the treble −3dB frequency, both in hertz. This seems realistic for f_b values from 20Hz to 300Hz, and above 300Hz you can't get a balanced frequency response at all: 400Hz to 2·8kHz sounds lacking at both ends simultaneously, for example.

Speech Microphones

For maximum clarity and intelligibility of speech, a flat or falling response below 250Hz is desirable, with a broad and not too prominent lift (no more than 6dB, certainly) between 2kHz and 4kHz. However, all microphones give a *rising* low frequency response when used close to the mouth (within 600mm), and this effect is particularly severe for directional microphones. Microphone preamplifiers and mixers should therefore include bass-cut controls to compensate for this effect, and ideally they should have an optional ultimate slope of 12dB/octave for use with directional microphones: the conventional control has an ultimate slope of only 6 dB/octave. Microphones used for outdoor sound reinforcement, narrow-band communications and the like, where intelligibility is more important than natural sound quality, should either not have an extended frequency response or should have the response band-limited at an early stage in the preamplifier: there is nothing to gain and lots of headroom to lose by amplifying signals that are not going to be reproduced.

Continued on page 67

Introducing The Man

Robert Arthur Penfold is probably the most well-known author in the fields of electronics, electro-music, radio and computers. Virtually everyone who enjoys the hobby of electronics has read at least one, if not more, of his books. Indeed over the past twenty years, he has written and had published over ninety books (over fifty of which Maplin stock!). In addition, he has also designed many projects and written innumerable articles, which have been published in the popular electronics press. As such Robert is probably the most successful and prolific writer of popular technical books that the wide-world of electronics and akin fields, has known. For such a successful writer, most people know very little about him. In this exclusive 'Face-to-Face' interview we will all learn more about the person behind the well-known name.

Ed. How and when did you first become interested in electronics?

R.A. Penfold. *Well, it all started off when my brother, John – he also writes books too you know – got hold of a radio kit that he'd seen advertised in the Daily Express. I was interested in what he was doing – well aren't all brothers? And from then on I was hooked. I must have been about seven, so that would have made it 1960.*

Ha! Now we know how old you are!!! Are you sure you want that printed?

It doesn't worry me, you can print it if you like!

What sort of projects did you build at first?

Mainly radio receivers, which were all that were readily available at the time. In those days Lasky's sold radio receiver kits and other electronics bits and pieces – a bit different to the current things they sell! I wonder what Maplin will be selling in 30 years time? – Anyway, back to the radio kits, one particular kit was called the 'Volksradio'. It was a simple one-valve regenerative receiver that covered the AM medium wave band. It relied on a long-wire aerial stretched the length of

"And from then on I was hooked"

the garden – not a ferrite-rod in sight anywhere! It worked, but not brilliantly well, tuning was about as broad as a barn-door. With far fewer stations than we're used to today, it was okay. I'm sure the only station it would receive clearly nowadays is Essex Radio! The 're-gen' was a way of getting more gain from a single stage amplifier, it works by feeding the signal through the same stage

Robert Penfold (left) and Robert Ball, Editor of 'Electronics'.

FACE TO

R.A. Penfold interview

FACE

ewed by the Editor

several times – positive feed-back really – by means of a re-gen control. The trouble is that if you advance the re-gen to far the radio would break into RF oscillation, howl like mad and re-transmit back up its own aerial! It would jam transmissions for a few hundred yards, great if you wanted to get your own back on the neighbours.
I went on to build a succession of audio amp's and radios which led me onto short wave listening. I started to study for the RAE exam, but became side-tracked by designing my own projects – the usual sort of things – VXOs, moisture, light and touch switches, and so on.

How did you get started in writing?

After leaving school at 16 I worked for the Post Office in the division that is now known as BT, not in engineering as you might expect but in the clerical side of things. I didn't stay there very long, about eight months – I suppose the engineering side would have been more appropriate – then I went on to work for a number of

"I wasn't convinced that writing would be a successful avenue to follow"

other companies, none of which I really liked. I also took a job with a company in London as a trainee draughtsman, but the travelling expenses and college fees amounted to more that I was earning, so that went by-the-board too. In the end, with a lot of encouragement and support from my parents, I started writing at home about electronics. It took quite a while to really get off the ground, about two years in all, after that time I was having articles published quite regularly.

Did you start by writing books or articles?

Articles only for a long while; I wasn't all that convinced as to whether writing would be a successful avenue to follow – articles were a fairly gentle introduction to writing and also a way of not putting all the eggs in one basket. After all, you can write quite a few articles in the same time as it takes to write a book. If an article doesn't get published it is not such a blow as not getting a book published after working on it for a couple of months.

What were your first published articles?

Ah, now the very first was an audio amplifier which was published in 'Practical Wireless' – 1971 if I remember correctly – after that came a signal generator in 'Radio Constructor'. Do you remember 'Radio Constructor', it disappeared from the newsagents' shelves quite a few years ago now.

Yes, I do remember it – that was the mag. with the really gaudy covers wasn't it? Yellow and pink and colours like that.

Just like some of your magazine pages then!

Okay! Point taken; actually I've pinched the artists coloured pencils so that should stop 'em!

Bet it won't!

Well wait and see! – Anyway, that's drifted off the point a bit! How did your first book come about – did you think of a subject for a book, write it and then send it to a number of publishers?

Actually, no! It happened the other way around, a publisher contacted me and asked if I was interested in writing a book.

How did the publishing company find out about your talent for writing about electronics and how did they contact you?

The publisher – Bernard Babini – saw my articles and projects in the electronics mag's and tried to get in contact through the magazine. They wouldn't pass on my address – which was only proper anyway – but managed to get the magazine to pass on a letter to me with a stooge query on a project.

What was the book called? Is it still in print?

The book was 'Solid State Short Wave Receivers for Beginners' – Maplin used to sell it until it went out of print. The only reason for its demise is that the Denco range of coils are no longer made.

How do you go about writing your books? – I mean the actual process of getting your ideas down on paper, not thinking up the ideas. And how has modern technology helped?

Initially I used to write articles by hand and then type them up on a conventional typewriter. As I became more keyboard proficient and more sure of exactly what I wanted to say, I started writing directly from the keyboard. Not having to write things twice, as it were, sped things up dramatically. Technology and, in particular, computers, has made life a lot easier. I use a Dell PC-AT running a word processing program to write with. It allows much greater flexibility in changing things and moving text around. I also use the Dell for CADding drawings and PCBs – Viewtrax and Board Maker 2, again it makes things a lot quicker.

"Technology and, in particular, computers, has made life a lot easier."

How long does it take you to write a book?

The quickest I've written a book is about 8 days, that was about 20,000 words and the longest about 2 months and that one was over 60,000 words plus lots of diagrams. The time taken doesn't just depend on the actual writing time, but also the time taken to research topics and get hold of all the information necessary to write the book.

Apart from Bernard Babini, who else publishes your books?

Butterworths and also Phillip Chapman are really the only others, but that's because it's a fairly specialist field.

Has the balance of book writing and article writing changed much over the years?

Yes, it has, mainly in favour of book writing, in the past I used to write around 50 or so articles and projects, and 5 or 6

"a publisher contacted me and asked if I was interested in writing a book."

books; now it's about 8 books and 36 articles. The balance has changed because in the long run books give the author a better return than articles. A book carries on selling for years bringing in the royalties, but magazines pay one-off fees and that's it. Articles are best at first for anyone who is interested in writing – because the returns are quicker and people become familiar with the author's name. After a while a switch to book writing is a good idea, but it's best not to stop writing articles otherwise people think you've snuffed it, emigrated or the like.

Which magazines do you write for?

Everyday Electronics, International Musician, Practical Electronics, Electronics Today International and of course Electronics – The Maplin Magazine!

What's brewing for our readers?

Some more 'Bob's Mini Circuits' – when will you publish them?

That's easy – in the next MONTHLY issue of 'Electronics'!

I'm sure that when I've read through other magazines that I've recognised your style of writing but under a different name, do you use pen-names and pseudonyms?

Yes I do, mainly at the request of the magazine Editors – I think it's because it gives the impression that they have a larger number of authors writing for them than they actually have! It used to be quite a prevalent practice but it seems to have largely passed out of fashion now.

Can I persuade you to reveal some of your secret identities?

Okay, there's about eight I've used, but A. P. Roberts, The Prof and M. V. Hastings are the ones I've used most frequently – you can try and guess the rest, but no prizes!

Apart from electronics and the like, what other things interest you, and what hobbies and pastimes do you have?

I collect cameras – Russian ones in particular, Zeniths – and I enjoy photography as well as collecting them; I don't see the point in just letting them sit on the shelf collecting dust. I also enjoy astronomy; painting – portraiture and landscapes in both oils and pastels; listening to and playing music and rearing butterflies.

What sort of photographic topics interest you?

Mainly close-up wildlife macro and micro photography, which is where the butterfly rearing comes in. I also photograph landscapes and paint them afterwards – British weather being what it is!

You mentioned music, what sort of music do you listen to?

An odd mixture really, Barbara Dixon, Kate Bush and Classical!

I suppose that since you've written a lot of books about electro-music you must play keyboards.

Yes, I've got a Roland D-110 synth., an Akai S-700 sampler, a Casio CZ1, a Mirage rack sampler and an Atari 520STFM with 1 Meg. of memory, running the C-Lab Notator sequencer and score notation package. The sound is routed through a home built mixer, amp and speaker system.

Returning to the subject of books – what are your best selling books?

"I've always fancied taking a trip on Concorde!"

The most successful book so far is the 'Beginners Guide to Building Projects'. The best selling recent books are the 'Practical MIDI Handbook' and 'Getting the Most from Your Multimeter'. Currently around 80,000 books a year are sold and so far the total is some 700,000 books.

You are already the most well-known and widely read author in the field of electronics, what ambitions do you have?

Well, apart from maintaining the popularity of the current books and writing new books, I would like to pursue music and art to more in-depth levels and also I've always fancied taking a trip on Concorde!

What books do you have in the pipeline?

There are plenty of ideas, most of which are a bit early to mention, but I will say that I've got some security related books lined up, so watch the bookstalls.

Thank you Robert for taking the time to talk about yourself and your books, I suppose it will be the famous *'Red Book'* next!

Bob's Best Books Competition

As a special prize for this issue's competition there is a set of Robert Penfold's Top Ten Best Selling Books to be won, all personally autographed. To enter, simply answer the questions below and send your answers *on a postcard or on the outside of a sealed envelope* to:

Bob's Best Books Competition,
'Electronics – The Maplin Magazine',
P.O. Box 3, Rayleigh, Essex, SS6 8LR.

Competition closes 31st October 1991. The first correct answer drawn from the new Editor's hat after the closing date will win. Only one entry per household please, multiple entries will be disqualified.

Questions:

1) How many books has Robert Penfold written?

a) 83
b) 85
c) 93
d) 95

2) In H.G. Wells's book 'War of the Worlds', which planet did the invaders come from?

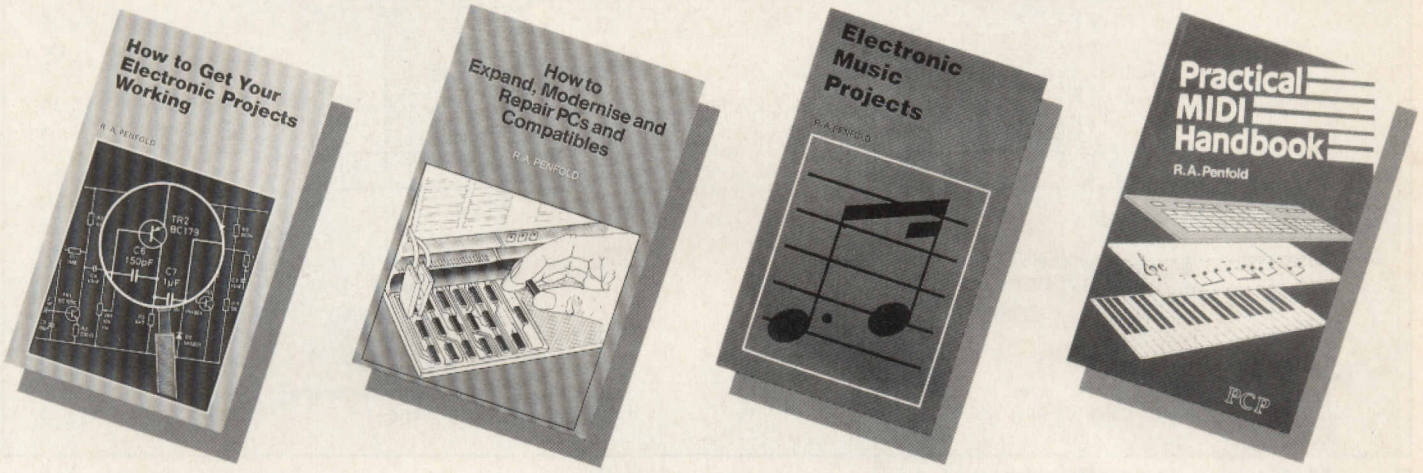
a) Zanussi
b) Mars
c) Crypton
d) Venus

3) How old is Robert Penfold?

a) 48
b) 38
c) 31
d) 52

4) Who is the Editor of *'Electronics – The Maplin Magazine'*?

a) Roy Smith
b) Robert Maxwell
c) Clarke Kent
d) Robert Ball



Bibliography

The following list of Robert Penfold's books includes Maplin Order Codes where appropriate, full descriptions of each of the books stocked may be found in the 1992 Maplin Catalogue.

Solid State Short Wave Receivers for Beginners	
50 Projects Using IC CA3130	
50 CMOS IC Projects	
How to Build Advanced Short Wave Receivers	
Beginners Guide to Building Electronic Projects	RF09K
Projects in Opto Electronics	LY05F
Popular Electronic Projects	RQ29G
Electronic Security Devices	RL43W
Second Book of CMOS IC Projects	
Single IC Projects	
Electronic Games	XW37S
Electronic Household Projects	
Electronic Music Projects	XW40T
Power Supply Projects	XW52G
Popular Electronic Circuits Book 1	XW67X
VMOS Projects	
An Introduction to Radio DXing	
Electronic Projects for Cars and Boats	
Model Railway Projects	WG60Q
CB Projects	
Popular Electronic Circuits Book 2	WG86T
Mini-Matrix Board Projects	WA35Q
Multi-Circuit Board Projects	
Aerial Projects	WA37S
Modern Op-Amp Projects	WA50E
30 Solderless Breadboard Projects Book 1	WA51F
How to Get Your Electronic Projects Working	WA53H
30 Solderless Breadboard Projects Book 2	WA55K
Practical Electronic Building Blocks Book 1	WK51F
Practical Electronic Building Blocks Book 2	WK52G
How to Design and Make Your Own PCBs	WK63T
Audio Amplifier Construction	WM31J
A Practical Guide to Microprocessors	
How to Design Electronic Projects	WM67X
Micro Interfacing Circuits Books 1	WM79L
Micro Interfacing Circuits Books 2	WP12N
An Introduction to Programming the Commodore C16 And Plus 4	
Computer Music Projects	WP38R
More Advanced Electronic Music Projects	WP44X
An Introduction to Computer Communications	
Electronic Circuits for the Computer Control of Robots	WP66W
Electronic Circuits for the Control of Model Railways	WP71N
MIDI Projects	WP49D
An Introduction to CP/M	
Electronic Synthesiser Construction	WP53H
More Advanced Electronic Security Projects	WS25C
More Advanced Power Supply Projects	WP92A
Modern Opto Device Projects	WP74R
Electronic Hobbyists Handbook	WP84F
Getting the Most from Your Multimeter	WP94C
Digital Audio Projects	WS46A
Musical Applications of the Atari STs	WS24B
More Advanced MIDI Projects	WS43W
Test Equipment Construction	WS40T
More Advanced Test Equipment Construction	WS78K
A Concise Introduction to WordPerfect	WS80B
More Advanced Uses of the Multimeter	WS63T
How to Use Oscilloscopes and other Test Equipment	WS65V
How to Expand, Modernise and Repair PCs and Compatibles	WS95D
Simple Short Wave Receiver Construction	WT16S
Short Wave Superhet Receiver Construction	WT43W
High Power Audio Amplifier Construction	
Understanding PC Specifications	WT26D
A Beginners Guide to Modern Electronic Components	WT61R
Understanding PC Software	
Audio Preamplifier and Filter Circuits	
Short Wave Accessory Projects	
An Introduction to Programming the Oric 1	
An Introduction to Programming the Dragon 32	
An Introduction to Programming the BBC Model B Micro	
An Introduction to Programming the Acorn Electron	
An Introduction to Programming the Atari 600/800 XL	
An Introduction to 6502 Machine Code	WM92A
An Introduction to Programming the Sinclair QL	
An Introduction to Z80 Machine Code	WP11M
An Introduction to Programming the Amstrad CPC464	
An Introduction to MSX BASIC	
An Introduction to QL Machine Code	
An Introduction to Computer Peripherals	
An Introduction to 68000 Assembly Language	WP54J
An Introduction to the Amstrad CPCs	
Computer Hobbyists Handbook	WS45Y
An Introduction to Desk Top Publishing	
Electronic Projects in the Workshop	
Electronic Projects in Audio	
Electronic Projects in Photography	
Electronics – Build and Learn	
Practical MIDI Handbook	
Electronics – Build and Learn (2nd Edition)	WP97F
Computers and Music	WS52G
Synthesisers for Musicians	WS32K
Practical MIDI Handbook (2nd Edition)	WP96E
Advanced MIDI Handbook	WT52G

Car Audio Switching PSU Continued from page 23

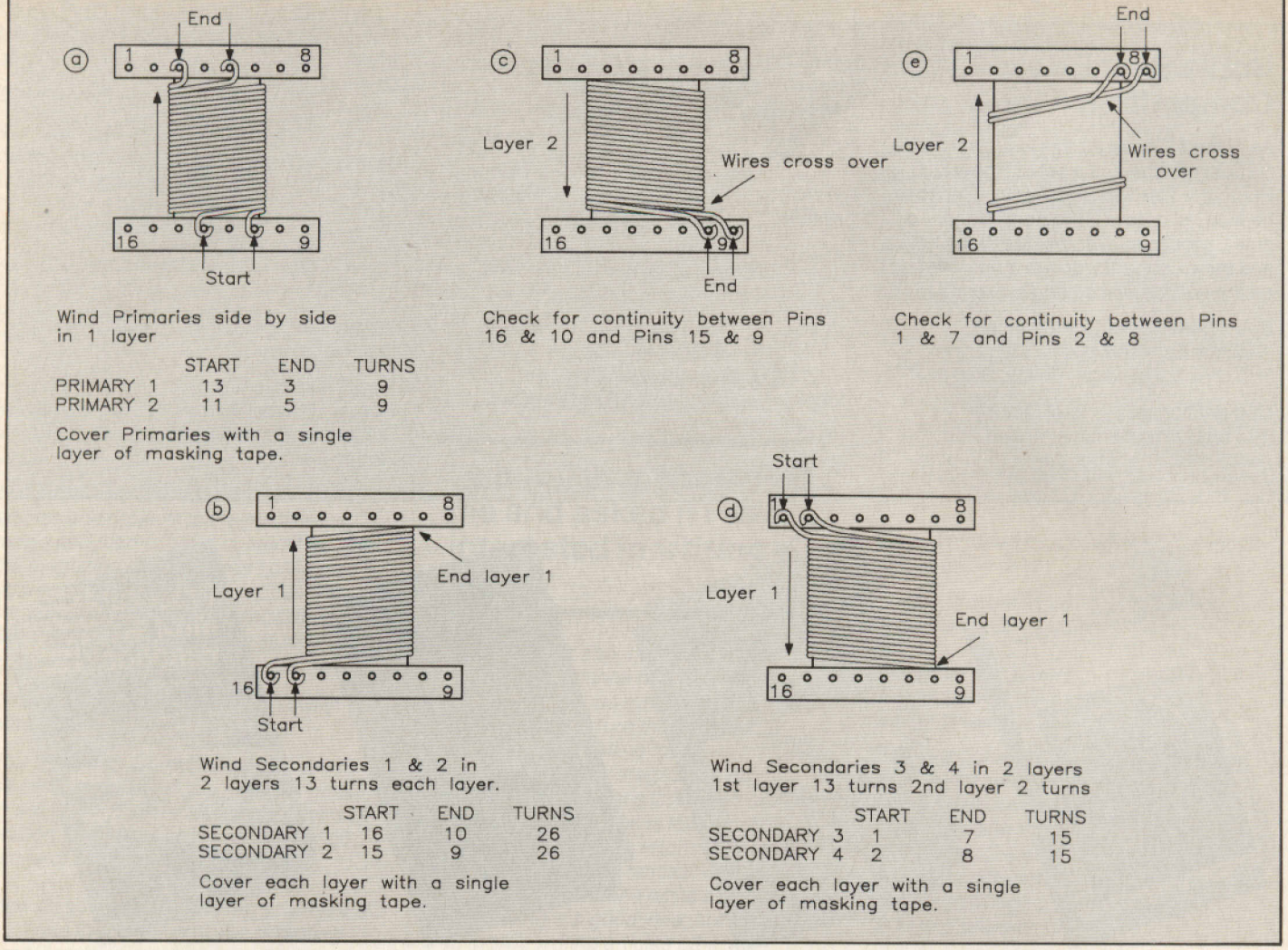

a
End
1
8
16
9
Start
Wind Primaries side by side in 1 layer
START END TURNS
PRIMARY 1 13 3 9
PRIMARY 2 11 5 9
Cover Primaries with a single layer of masking tape.
c
Layer 2
Wires cross over
End
Check for continuity between Pins 16 & 10 and Pins 15 & 9
e
End
Layer 2
Wires cross over
Check for continuity between Pins 1 & 7 and Pins 2 & 8
b
Layer 1
End layer 1
Start
Wind Secondaries 1 & 2 in 2 layers 13 turns each layer.
START END TURNS
SECONDARY 1 16 10 26
SECONDARY 2 15 9 26
Cover each layer with a single layer of masking tape.
d
Start
Layer 1
End layer 1
Wind Secondaries 3 & 4 in 2 layers 1st layer 13 turns 2nd layer 2 turns
START END TURNS
SECONDARY 3 1 7 15
SECONDARY 4 2 8 15
Cover each layer with a single layer of masking tape.

Figure 15. Transformer winding details.

be approximately 400mA. If an oscilloscope and/or frequency counter are available then these may be used to confirm that a 50kHz (approximately) sawtooth waveform is available on P24. Avoid undue capacitive loading otherwise the frequency of the oscillator will be shifted.

Unlink P3 and P1, disconnect the supply and disconnect the multimeter. Reconnect the supply and re-link P3 and P1. Measure the voltage on the output pins, using a suitable voltage range. P4 to P7 should read +30V with respect to P8. Pins P12 to P15 should read −30V with respect to P8. P16 should read +12V with respect to P17 and P18 should read −12V with respect to P17.

The thermal shutdown circuit may be tested by carefully heating the thermistor with a hairdryer. When the thermistor reaches a temperature of approximately 80°C the thermal shutdown LED (LD2) will illuminate and the power supply will shutdown, this can be confirmed by measuring one of the supply voltage outputs. When the thermistor temperature drops to approximately 60°C the power supply will restart and the thermal shutdown LED will extinguish.

This completes testing of the power supply.

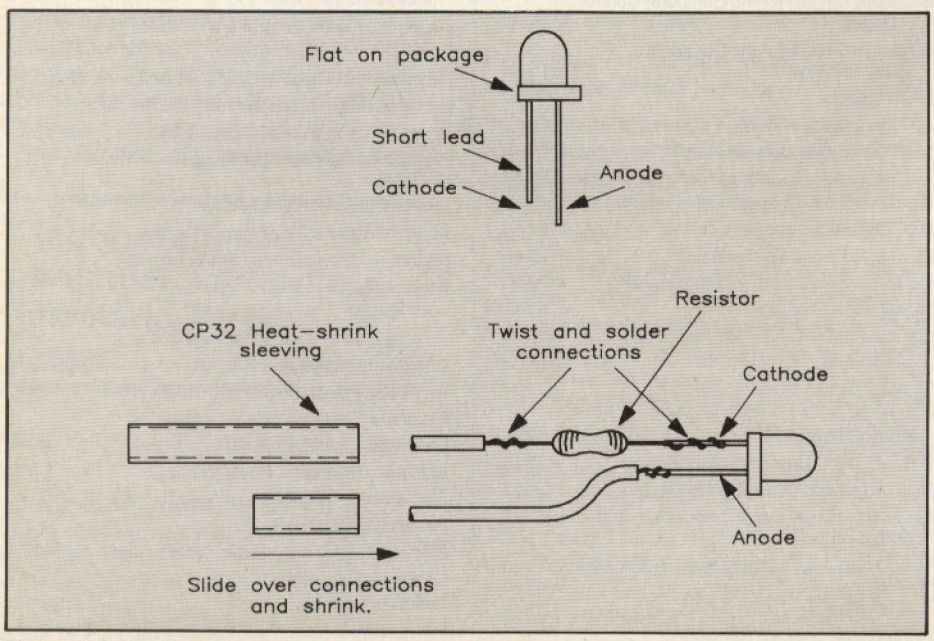


Figure 16. LED leadout identification and connections.

Constructional details for the 50W bipolar amplifier are published in the Projects section of the Maplin Catalogue, constructional details are also supplied with each amplifier kit. Photo 6 shows the 50W Bipolar Amplifier.

As previously stated, the power supply is specifically intended for use with two Maplin 50W Bipolar Power Amplifiers. In most applications the audio output power attainable from these amplifiers when used in conjunction with this power supply should be more than sufficient for in-car use. However the purist may wish to use separate power supplies for each amplifier to increase the power available per channel. Similarly if a single channel subwoofer amplifier is required, a single

amplifier may be driven from one power supply. It should be pointed out that excessive sound pressure levels may lead to long term, irreversible hearing problems. High levels of sound may also blot out other external sounds, which could be dangerous when on the move. Please use common sense when using a high power in-car entertainment system.

It is strongly recommended that the power supply is fully cased and provided with an additional external heatsink, type 2E is suggested. Metal cases are ideal for this purpose, and also provided a degree of shielding against radiated radio frequency emissions. The audio amplifiers may also be housed in the same case, which could be conveniently mounted in the car boot or under a seat. The audio amplifiers should also be heatsinked, again type 2E is suggested.

To connect the 50W Bipolar amplifiers to the power supply, treat the switching power supply as a conventional power supply (as shown in the amplifier constructional details) and connect accordingly (HT1 and HT2 are positive, HT3 and HT4 are negative). Refer to Figure 11 for connections to the power supply. The amplifier set-up procedures should be followed in the same way as for the conventional power supply. Connections from the power supply to the amplifiers should be made using 32/0·2 wire.

Loudspeakers should be suitably rated for high power use. Beware, many car loudspeakers are given misleadingly high power ratings, try and find out what the true RMS ratings are. Usually car loudspeaker ratings are giving in peak power or total peak power, be prepared to divide the rating by 1·414 or even 2·828! Loudspeaker wiring should also be sufficiently rated for the purpose.

Connections from the power supply to the car electrical system should be made using very heavy duty cable. It is advisable to connect the power supply directly to the car battery via its own in-line fuse at the car battery end. Assuming a negative earth car, the chassis may be used to provide the 0V connection, which saves on wire.

CAR AUDIO SWITCHING PSU PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	6k8	1	(M6K8)
R2	68k	1	(M68K)
R3,35	1k2	2	(M1K2)
R4,5,6,7	56Ω	4	(M56R)
R8,36	10Ω	2	(M10R)
R9,10	1k 3W	2	(W1K)
R11,12	470R 3W	2	(W470R)
R13,17,22,23, 26,27,28,29,34	1k	9	(M1K)
R14,19,21,31, 32,33	10k	6	(M10K)
R15	24k	1	(M24K)
R16,20,24,25	4k7	4	(M4K7)
R18	1M	1	(M1M)
R30	3k3	1	(M3K3)
TH1	Bead Thermistor 15k	1	(FX22Y)
CAPACITORS			
C1,5,15,16,25, 26,28,30	100nF Polyester	8	(BX76H)
C2,13,14	220µF 50V SMPS	3	(JL51F)
C3,4,11,12	1000µF 50V SMPS	4	(JL57M)
C6,31	2n2F 1% Polystyrene	2	(BX60Q)
C7,8,9,10,17,18, 19,20	560pF Ceramic	8	(WX65V)
C21,22	1000µF 25V SMPS	2	(JL56L)
C23,24	10µF 25V Tantalum	2	(WW69A)
C27	100µF 25V PC Elect	1	(FF11M)
C29	22µF 25V PC Elect	1	(FF06G)
C32	10µF 16V Tantalum	1	(WW68Y)
C33,34	150pF Polystyrene	2	(BX29G)
D1,2	1N4001	2	(QL73Q)
D3,4,13,14,15, 16,17,18	1N4148	8	(QL80B)
D5,6,7,8	BYW80-150	4	(UK63T)
D9,10,11,12	BYW98-150	4	(UK65V)
ZD1,2	BZX61C/BZX85C 39V	2	(QF67X)
TR1	BC337	1	(QB68Y)
TR2,3,4,5	BUZ11	4	(UJ33L)
TR6,7,8,9,10	BC559	5	(QQ18U)
LD1,2	Red LED	2	(WL27E)
RG1	µA7812UC	1	(QL32K)
RG2	µA7912UC	1	(WQ93B)
IC1	TL494	1	(RA85G)
IC2	LM311	1	(QY09K)
MISCELLANEOUS			
L1	FX4054 Ferrite Toroid	1	(JR84F)
L2,3	RF Suppressor 3A	2	(HW06G)
T1	ETD39 Ferrite Core	2	(JR81C)
	ETD39 Former	1	(JR82D)
	ETD39 Clip	2	(JR83E)
RL1	12V 16A Relay	1	(YX99H)
FS1	15A 1¼in AS Fuse	1	(UK13P)
FS2,7	100mA 20mm QB Fuse	2	(WR00A)
FS3,4,5,6	2A 20mm AS Fuse	4	(WR20W)
	1¼in Chassis F/Holder	1	(RX50E)
	Fuse Clip	12	(WH49D)
	Isobolt M3 6mm	1Pkt	(BF51F)
	Isobolt M2·5 12mm	1Pkt	(BF55K)
	Isonut M3	1Pkt	(BF58N)
	Isonut M2·5	1Pkt	(BF59P)
	Isoshake M3	1Pkt	(BF44X)
	Isoshake M2·5	1Pkt	(BF45Y)
	Isotag M3	1Pkt	(LR64U)
	TO220 Insulator	8	(QY45Y)
	TO220 Bush Long	1Pkt	(UL69A)
	50W Heatsink	1	(HQ69A)
	16-pin DIL Skt	1	(BL19V)
	8-pin DIL Skt	1	(BL17T)
	Pins 2145	1Pkt	(FL24B)
	PCB	1	(GE61R)
	TC Wire 0·9mm 20swg	1 Reel	(BL13P)
	TC Wire 1·6mm 16swg	1 Reel	(BL11M)
	Wire 3202 Green	1mtr	(XR35Q)
	EC Wire 1·6mm 16swg	1 Reel	(BL24B)
	EC Wire 1·25mm 18swg	1 Reel	(BL25C)
	EC Wire 0·71mm 22swg	1 Reel	(BL27E)
	Lapped Pair	1mtr	(XR20W)
	Heat Shrink CP 32	1mtr	(BF88V)
	Heat Shrink CP 16	1mtr	(BF86T)
	Constructors' Guide	1	(XH79L)
	Instruction Leaflet	1	(XK50E)
OPTIONAL (not in kit)			
	Car Fuse Holder	1	(RX51F)
	15A 1¼in AS Fuse	1	(UK13P)
	HC Wire Black	As Req	(XR57M)
	HC Wire Red	As Req	(XR59P)
	32/0·2 Wire Red	As Req	(XR36P)
	32/0·2 Wire Black	As Req	(XR32K)
	32/0·2 Wire Blue	As Req	(XR33L)
	Zip Wire	As Req	(XR39N)
	50W Power Amp	2	(LW35Q)
	2E Heat Sink	2	(HQ70M)

The Maplin 'Get-You-Working' Service is available for this project, see page 15 for details.

The above items are available as a kit (excluding Optional), which offers a saving over buying the parts separately.

Order As LP39N (Switching PSU Kit) Price £39.95 A

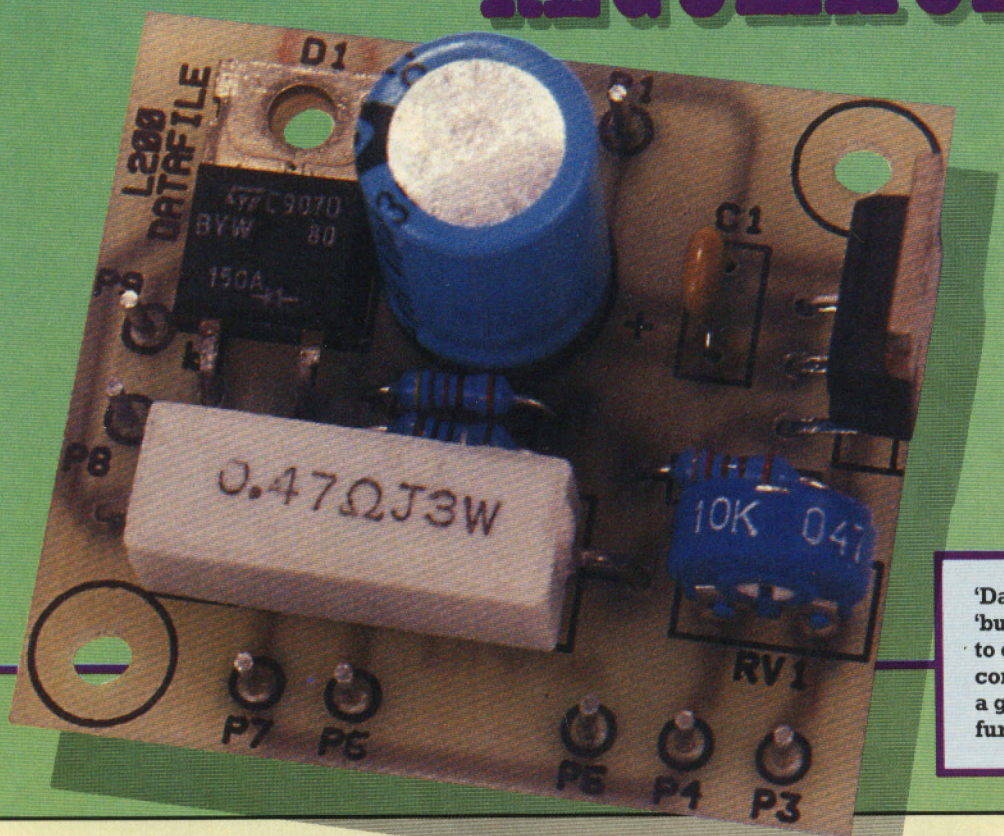
Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately.

Switching PSU PCB **Order As GE61R Price £6.25**

DATA FILE

L200 ADJUSTABLE VOLTAGE/CURRENT REGULATOR



'Data Files' are intended as 'building blocks' for constructors to experiment with and the components supplied provide a good starting point for further development.

FEATURES

★ Adjustable output current ★ Adjustable output voltage ★ Low quiescent current
★ Short circuit protection ★ Thermal overload protection

APPLICATIONS

★ Power supplies ★ Battery chargers ★ DC–DC converter

Parameter	Conditions	Min.	Typ.	Max.
DC input Voltage	Absolute Maximum			40V
Quiescent Current Drain (pin 3)	Input Voltage (V_i) = 20V		4·2mA	9·2mA
Output Voltage Range	Output Current = 10mA	2·85V		36V
Operating Junction Temperature Range (L200C)	Absolute Maximum	−25°C		+150°C
Line Regulation	V_i = 8V to 18V, V_o = 5V	48dB	60dB	
Dropout voltage between pins 1 and 5	Output Current = 1·5A $\Delta V_o \leq 2\%$		2V	2·5V
Reference Voltage (pin 4)	Input Voltage (V_i) = 20V Output Current (I_o) = 10mA	2·64V	2·77V	2·86V

Table 1. L200 typical electrical characteristics.

Introduction

The L200 is a monolithic IC designed for programmable voltage and current regulation. Voltage outputs between 2·85V and 36V may be accommodated, at currents of up to 2A. The device is supplied in a 5-pin package; the IC pin-out is shown in Figure 1. The L200 has internal protection to minimise the possibility of damage to the device; this comprises current limiting, power limiting, thermal shutdown and input over-voltage protection (up to 60V for 10mS). Table 1 shows typical electrical characteristics for the device. In addition some typical performance figures are shown in Figure 2.

General Description

As can be seen from the block diagram shown in Figure 3, the L200 regulator uses a relatively sophisticated design. The device may be used in several different configurations to provide voltage or current regulation.

Current limiting is controlled by connecting a resistor between pin 2 and pin 5 of the L200. The current limit

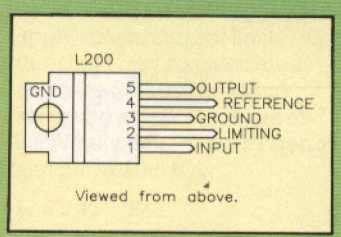


Figure 1. L200 IC pinout.

threshold is approximated by the expression:

$I_o = V_{sc} \div R_{sc}$

where:

I_o = Output Current (A)
V_{sc} = Current Limit Sense Voltage (V)
R_{sc} = Resistance between pin 5 and pin 2 (Ω)

The current limit sense voltage is variable depending on several factors including load and temperature but is typically 0·45V.

Power dissipation is controlled by the internal Safe Operating Area (SOA) protection circuitry of the L200. The device can supply a current of up to 2A as long as the input/output differential voltage is less than 20V. With differential

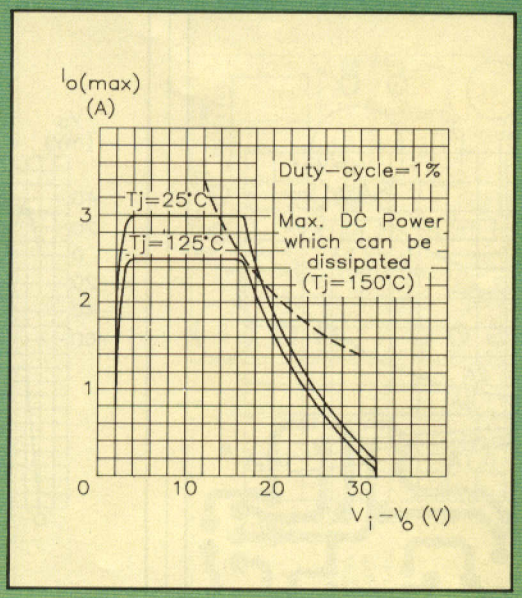


Figure 2a. Typical safe operating area protection.

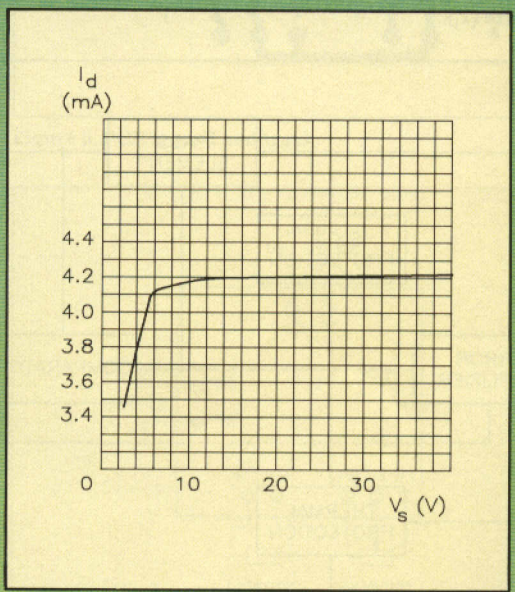


Figure 2b. Quiescent current (I_d) vs. voltage (V_s).

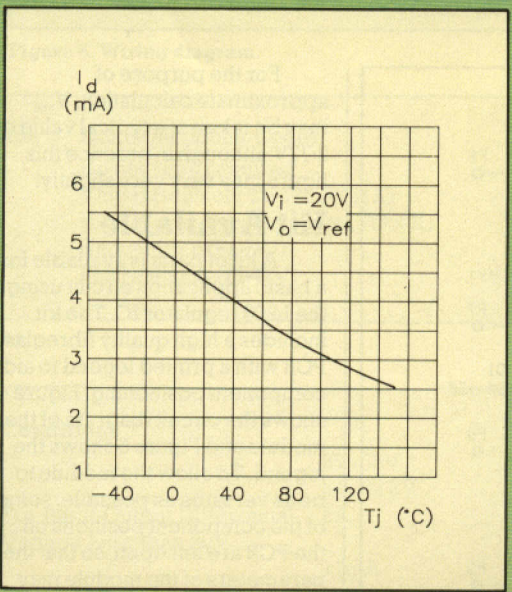


Figure 2c. Quiescent current (I_d) vs. junction temperature (T_j).

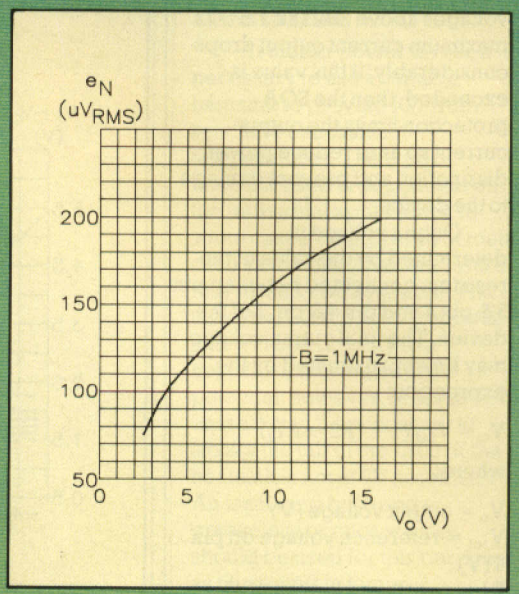


Figure 2d. Output noise voltage (°N) vs. output voltage (V_o) for 1MHz bandwidth.

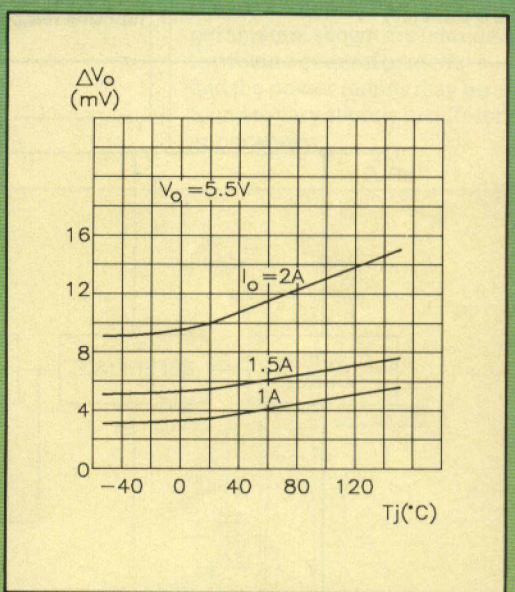


Figure 2e. Voltage load regulation (ΔV_o) vs. junction temperature (T_j).

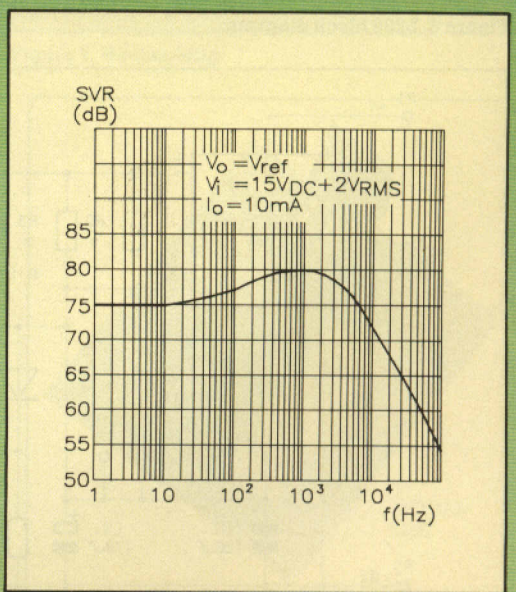


Figure 2f. Supply voltage rejection (SVR) vs. frequency (*f*).

voltages above 20V the maximum current output drops considerably; if this value is exceeded, then the SOA protection limits the output current so as to reduce power dissipation and prevent damage to the device.

Output voltage is determined by the value of the resistors connected between pin 3 & pin 4 and pin 4 & pin 2 of the device. The final output voltage may be approximated by the expression:

$V_o = V_{ref}(1 + (R2 \div R1))$

where:

V_o = output voltage (V)
V_{ref} = reference voltage on pin 4 (V)
R1 = resistance between pin 4 & pin 3 (Ω)
R2 = resistance between pin 2 & pin 4 (Ω)

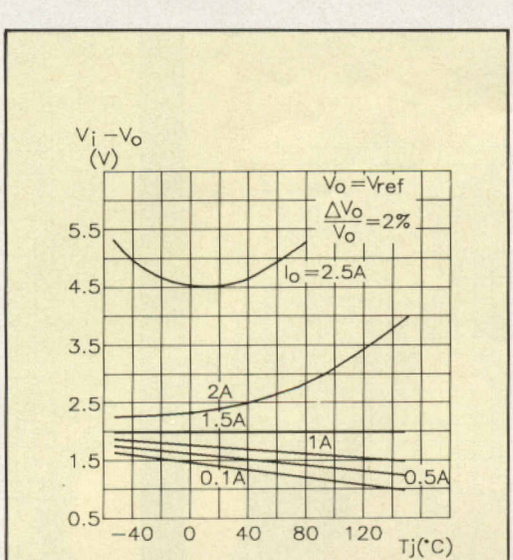


Figure 2g. Dropout voltage ($V_i - V_o$) vs. junction temperature (T_j).

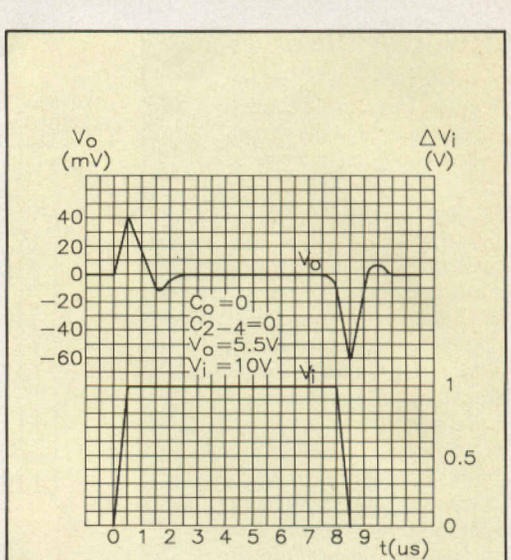


Figure 2h. Voltage transient response.

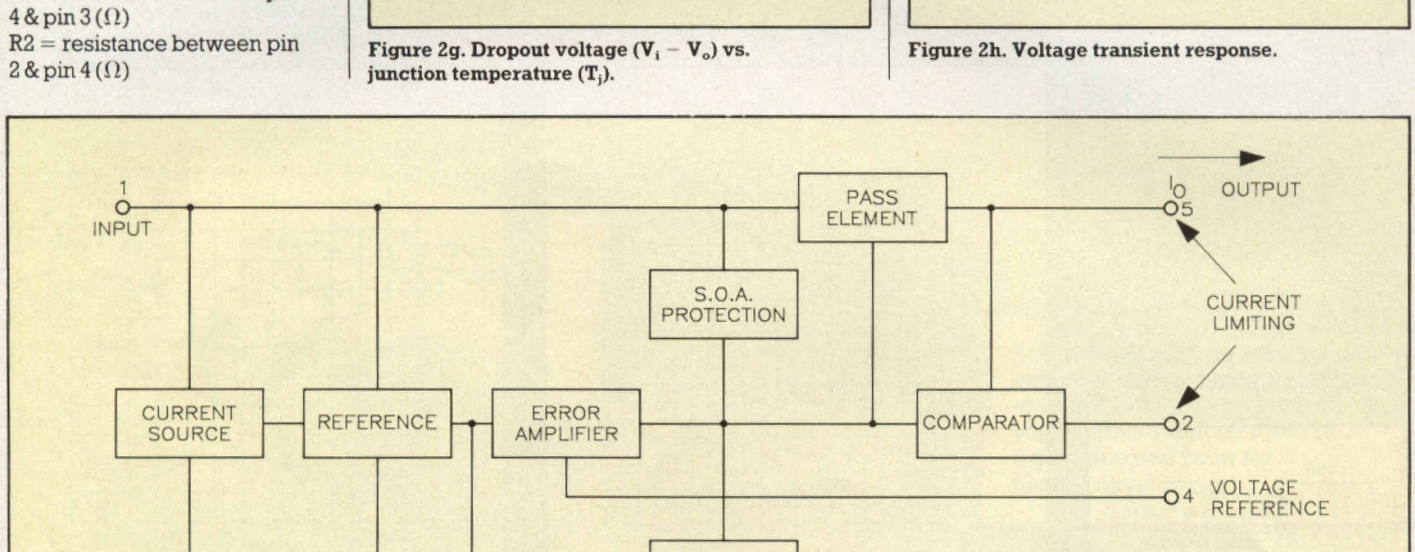


Figure 3. L200 block diagram.

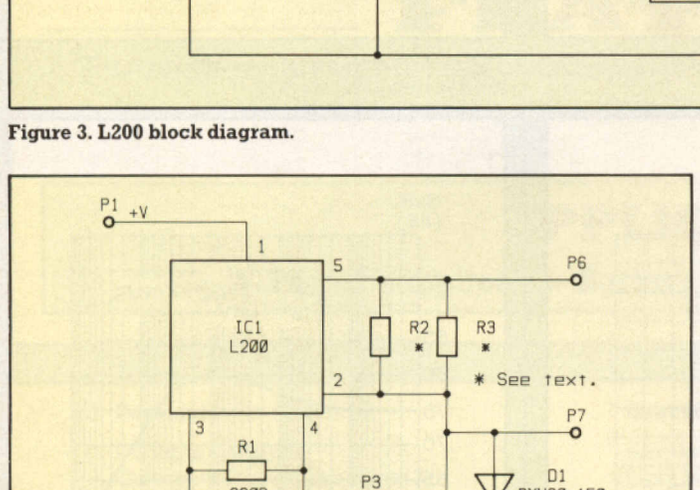


Figure 4. Module circuit diagram.

For the purpose of approximate calculation, V_{ref} may be taken at a typical value of 2·77V although in practice this figure may vary very slightly.

Kit Available

A kit of parts is available for a basic application circuit using the L200 regulator IC. The kit includes a high quality fibreglass PCB with a printed legend to aid component positioning. Figure 4 shows the circuit diagram of the module and Figure 5 shows the legend. To allow the module to be as versatile as possible, some of the component positions on the PCB are left open, so that the parameters of the module may be determined by the user. In particular, the values of resistors R2 and R3 (which determine the current limiting threshold of the regulator) are subject to selection, depending on the individual application.

For connection information reference should be made to the wiring diagram shown in Figure 6. Input connections to the module are made to P1 (Input +V) and P2 (0V). Output connections are made to P8 (Output +V) and P9 (0V).

To maintain correct regulation, it is important that the input/output differential voltage is never allowed to fall below the regulator dropout voltage. The dropout voltage may vary but as a general rule, it is recommended that the input voltage is always at least 4V

above the maximum required output voltage.

Output voltage control is via preset resistor RV1. Provision is also made for an external voltage control potentiometer and this may be connected to P3, P4 and P5. If an external voltage control is used, then RV1 should NOT be fitted. If a fixed output is required, then a fixed resistor may be connected between P3 and P4; once again, RV1 should NOT be fitted as this is effectively in parallel with any external voltage control resistors.

The current limit threshold of the module is set by resistors, R2 and R3. Two Parallel resistors are used to enable the very low values of resistance required for higher current limit thresholds to be achieved. It should be noted that R3 may either be a 0·6W or a 3W type and a separate set of holes is provided for both types. For some applications it may of course be possible to achieve the correct value using one resistor only. Provision is also provided for an external current limiting resistor, which may be connected between P6 and P7. A low value variable resistor may be used for variable current limit control but at higher current levels the resolution will become increasingly poor. The approximate current limit threshold may be calculated using the following method, assuming a typical voltage of 0·45V between P6 and P7 (pin 5 and pin 2 of the IC):

$I_o = 0{\cdot}45 \div Rsc$

where I_o is the output current and Rsc is the total parallel resistance between P6 and P7 (R2, R3 and any external current limit resistor in parallel) in ohms.

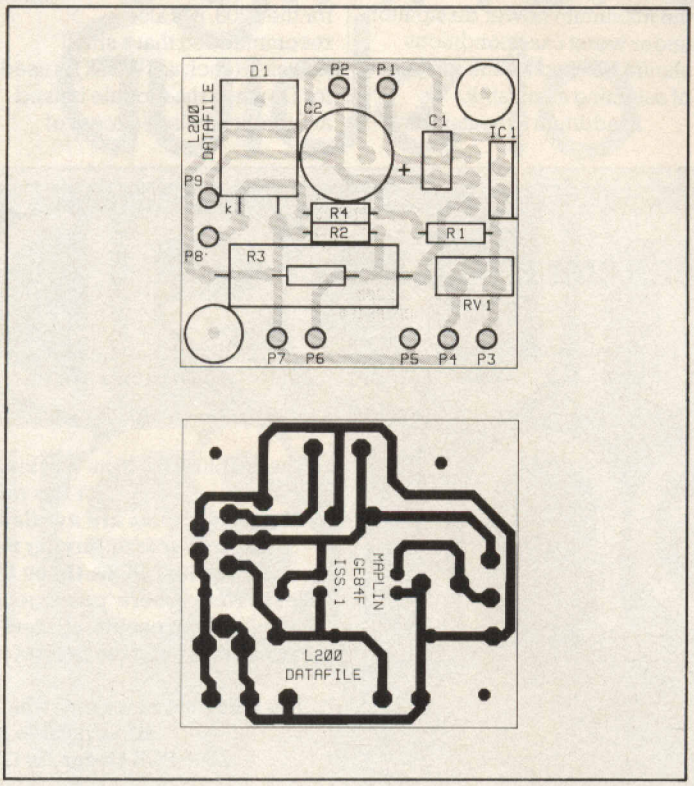


Figure 5. PCB legend and track.

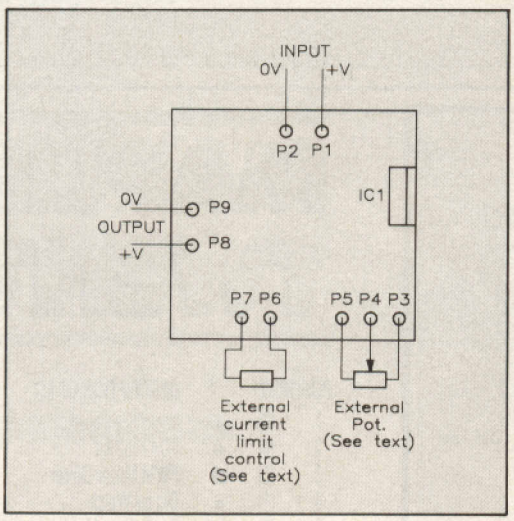


Figure 6. Wiring diagram.

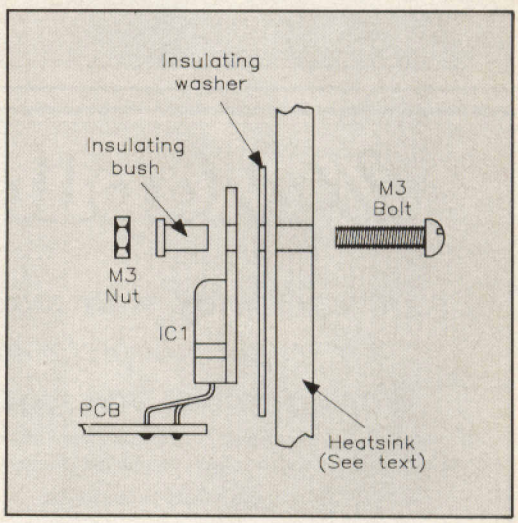


Figure 7. Heatsinking.

Heatsink

At higher power levels, it is necessary to use a suitable heatsink to prevent IC1 from reaching excessive temperatures. The type of heatsink used is dependant on the individual application. In some cases, a large area of metal such as the side of an enclosure may already be available. The tab of the L200 is at 0V potential and will bolt directly to a heatsink if this is also at 0V potential; however, in some cases it may be necessary to isolate the tab of the L200 (if the heatsink is not at 0V potential). An insulating bush and a greaseless or mica washer should be used for this purpose, as illustrated in Figure 7.

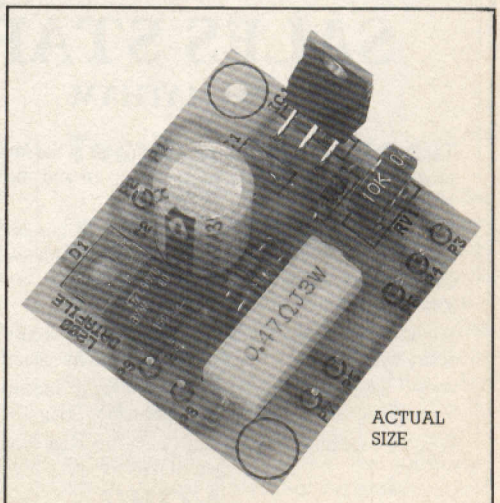
Typical heatsinks for use with the L200 up to 20W are shown in Table 2. The parameters shown are intended to provide general guidelines and the power ratings may be found to vary slightly in different applications.

Regulator Power Dissipation	Heatsink (Stock Code)
Up to 500mW	No heatsink required
500mW–1·5W	Vaned Heatsink TO126 (JX21X)
1·5W–3·5W	High Power Twisted Vane (FG55K)
3·5W–10W	Heatsink 4Y (FL41U)
10W–20W	Flat Heatsink (FL42V)

Table 2. Typical heatsinks for the L200.

Parameter	Conditions	
Input Voltage		5V–35V
Output Voltage		2·8–32·8V
Output Current (Max)	For Input/Output Differential Voltage Less than 20V	2A
Quiescent Current (Max)		11mA

Table 3. Specification of prototype module.



The assembled L200 module.

Please note: any of the higher power heatsinks are also suitable for lower power applications and where the power dissipation is variable, the maximum power dissipation under worst case conditions should be used for the purposes of selecting a heatsink.

In addition to heatsinking for the L200, it is also recommended that a small heatsink (such as JW21X) is used for D1 when the module is used at current levels in excess of 750mA; in this case D1 should be mounted vertically and the heatsink bolted to the tab. Table 3 shows the specification of the prototype module.

L200 VOLTAGE/CURRENT REGULATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)			
R1	820Ω	1	(M820R)
R2	*See Text*	1	
R3	*See Text*	1	
R4	4k7	1	(M4K7)
RV1	Vert Encl Preset 10k	1	(UH16S)
CAPACITORS			
C1	Monores Cap 100nF	1	(RA49D)
C2	PC Elect 470μF 35V	1	(FF16S)
SEMICONDUCTORS			
IC1	L200	1	(YY74R)
D1	BYW80-150	1	(UK63T)
MISCELLANEOUS			
P1-9	Pins 2145	1 Pkt	(FL24B)
	L200 PCB	1	(GE84F)
	Instruction Leaflet	1	(XT00A)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LP69A (L200 Data File) Price £3.95

Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately:

L200 PCB **Order As GE84F Price £1.28**

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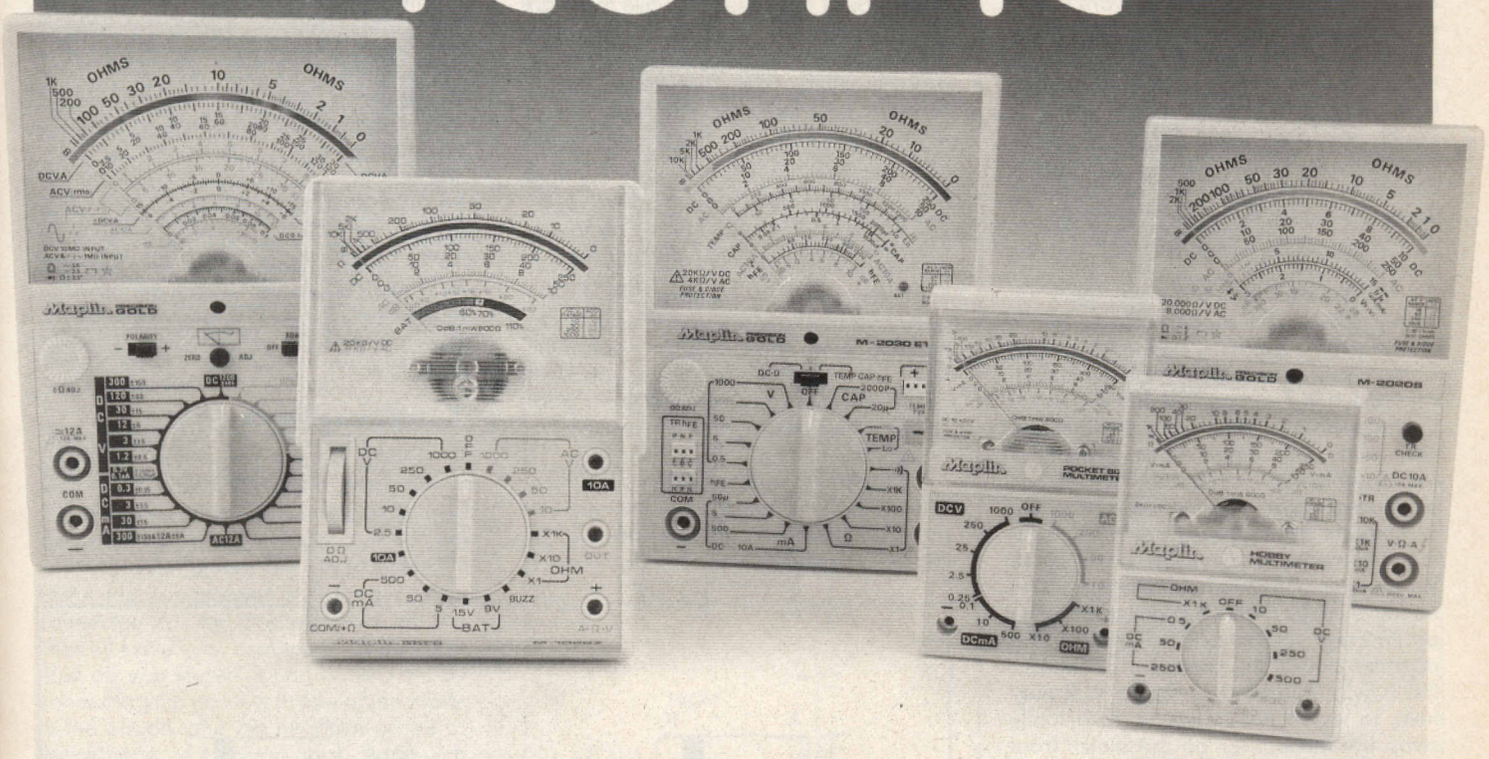
POSITION			DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN	
1.	(2)	♠	Live Wire Detector	LK63T	£ 4.25	Projects	14 (XA14Q)
2.	(4)	♠	TDA7052 Kit	LP16S	£ 4.45	Magazine	37 (XA37S)
3.	(3)	♦♦	PWM Motor Driver	LK54J	£ 9.95	Best of Book	3 (XC03D)
4.	(1)	♥	Digital Watch	FS18U	£ 2.45	Catalogue	'92 (CA09K)
5.	(5)	♦♦	Car Battery Monitor	LK42V	£ 7.95	Magazine	37 (XA37S)
6.	(10)	♠	Mini Metal Detector	LM35Q	£ 4.95	Magazine	25 (XA25C)
7.	(9)	♠	1/300 Timer	LP30H	£ 4.95	Magazine	38 (XA38R)
8.	(6)	♥	8W Amplifier	LW36P	£ 7.45	Catalogue	'92 (CA09K)
9.	(14)	♠	TDA2822 Amplifier	LP03D	£ 6.95	Magazine	34 (XA34M)
10.	(8)	♥	Partylite	LW93B	£10.25	Catalogue	'92 (CA09K)
11.	(11)	♦♦	I/R Prox. Detector	LM13P	£ 9.95	Projects	20 (XA20W)
12.	(17)	♠	Siren Sound Generator	LM42V	£ 4.25	Magazine	26 (XA26D)
13.	(13)	♦♦	LM386 Amplifier	LM76H	£ 3.75	Magazine	29 (XA29G)
14.	(7)	♥	U/Sonic Car Alarm	LK75S	£17.95	Projects	15 (XA15R)
15.	(12)	♥	15W Amplifier	YQ43W	£ 7.45	Catalogue	'92 (CA09K)
16.	(19)	♠	Watt Watcher	LM57M	£ 5.45	Magazine	27 (XA27E)
17.	(-)	RE-ENTRY	Audio Controlled Switch	LP29G	£ 5.95	Magazine	38 (XA38R)
18.	(-)	RE-ENTRY	Rec/Playback	LM80B	£29.95	Magazine	30 (XA30H)
19.	(16)	♥	TDA7000 Radio MK2	LM55K	£22.95	Magazine	27 (XA27E)
20.	(18)	♥	TDA1514 Power Amplifier	LP43W	£16.45	Magazine	40 (XA40T)

Over 150 other kits also available. All kits supplied with instructions.

The descriptions are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate project book, magazine or catalogue mentioned in the list above.

Beginner's Guide to CIRCUIT TESTING



Part 2 by R. Richards

The previous part introduced the essential basics of how to go about circuit testing. Now we go into more detail with the components themselves.

Testing Resistors

The principle was fully covered by the foregoing explanation of resistance measurements and illustrated in Figure 3. You should make allowance for the tolerance when checking resistors so that you can recognise that the value is reasonably correct and not a genuine error. If the circuitry is complex and/or there is no circuit diagram to hand, it will be necessary to disconnect the resistor at one end thus isolating it in order to establish its true value, which can be compared with its colour band code. Although extremely fiddly, and possibly hazardous to the components and board, in that much desoldering and resoldering is required, it is nevertheless the best way of verifying resistor values. Be warned that such removal and resoldering activities introduce the very real dangers of solder bridges and bad connections etc., so be patient and double check and rectify at every stage of the operation.

Testing Capacitors

Capacitors can be tested with the multimeter set to its highest resistance range and should give a very high reading of up to one megohm or more. Basically all this can do is verify whether the dielectric of the component is sound or not. The pointer may give a small kick before settling down to a high reading if the value of the capacitor is large enough, usually >100nF (0·1μF). This small movement indicates the charging of the capacitor, which at least shows that it is making some effort to behave like one. Any low reading would indicate leakage through a dam-

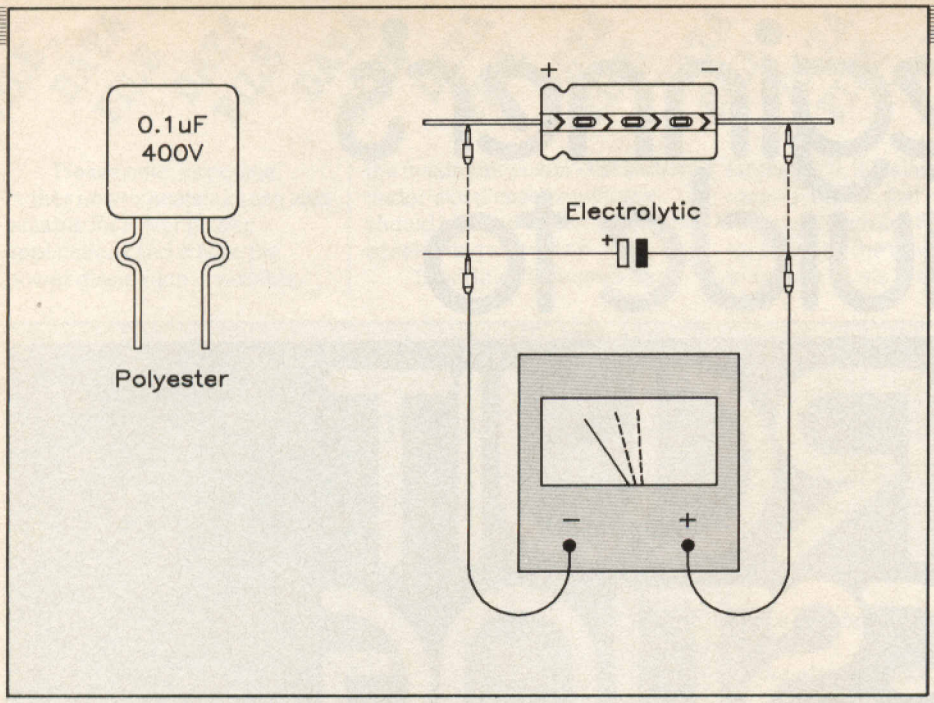


Figure 9. Testing capacitors. Note the pointer kick.

aged dielectric, however be aware that a small amount of leakage (high resistance) is usually normal, especially with electrolytics, which will also show a long charge time proportional to the value, giving a larger kick and taking longer to settle down to a high reading. Electrolytic capacitors often show readings that are lower in comparison with non electrolytics, i.e. a minimum of 30,000 to 50,000Ω is not necessarily a fault.

Electrolytics are polarised, and the negative side of a modern electrolytic is indicated by a minus ('−') sign with a black or dark stripe (or a light stripe on a dark background). It is important that you apply the test probes to these capacitors the right way round, with regard to the polarity of the instrument's ohmmeter circuit, as mentioned earlier. To reiterate, since the commonest arrangement is for the multimeter's negative probe to be connected to the *plus* side of its internal battery, then the negative probe should be connected to the *positive* side and the positive probe to the *negative* side of the capacitor under test. this is fully illustrated in Figure 9. It may help, to lessen the confusion, to actually swap the leads over on the meter front panel for these sorts of tests. It is however a waste of time changing the polarity reversal switch, if the meter has one, because this merely reverses the meter movement, and *not* the internal battery supply.

However non-polarised capacitors, as is the polyester example also shown in Figure 9, are not fussy which way round the test probes are applied. But small values won't produce the 'pointer kick', so while this can mean that the dielectric is sound if a very high reading is shown, it can also mean a broken internal connection and that the capacitor is actually open circuit and useless!

One big problem with checking capacitors that are wired into a circuit is that they invariably need to be removed, or at least disconnected at one end, to enable this sort of test to be done at all. This is because it is very difficult to test the resistance of the dielectric while there are other components like resistors bypassing the test current via another route. The big problem is that, while the greater part of resistors are fairly mechanically tough, many capacitors are fragile and easily broken by excessive physical force, or destroyed through overheating. Ceramic plate and disc, as well as polyester, types fall into the first category, while polystyrene types are particularly vulnerable to heat damage. This is aggravated by the need to remove solder bridges, which can become quite tenacious; to reintroduce wires through PCB pads now closed with hardened solder, to re-establish a good solder joint again afterwards, etc. etc. *ad nauseam.*

Moreover, without more specialised test equipment which can be used to actually determine the value of the capacitor, you will never be sure whether the component is genuinely 100% fit just because it passed a leakage test. Other ideas can be tried depending on what the capacitor's function is; for example, if it has a *decoupling* function (e.g. to stabilise a supply rail or similar DC path by providing a low AC impedance to ground), or a *coupling* function, which passes on AC to another stage but blocks DC, then if removing the component makes no difference whatsoever to the original fault it is an internally open circuit and has very little or no capacitance at all, so is not doing its job. Alternatively, if the action introduces *another* additional or totally separate fault then there is little wrong with that particular component! However if you happen to own the M-2030 ET multimeter then you are better off, as this instrument includes a capacitance tester with ranges of 2,000pF and 20μF, which can verify a component more accurately.

Capacitors commonly provide decoupling, coupling or resonant functions in electronic circuits, and depending on the specific function a fault may or may not be easily seen. Whereas a coupling failure is fairly obvious by the fact that the signal is not getting through properly, a decoupling problem has to produce gross instability or noise or similar abnormal behaviour to be noticed, or be found by looking for abnormal waveforms with an oscilloscope. We then start getting into the realms of the 'replace until cured' approach to fault finding, where components are systematically exchanged for new ones until the circuit works properly again, and which of course requires a 'stock' of replacement items.

Testing Inductors

Strictly speaking all coils, chokes and transformers should be tested for inductance, but again without the specific test gear all that can be done in practice is to make sure their DC resistance is reason-

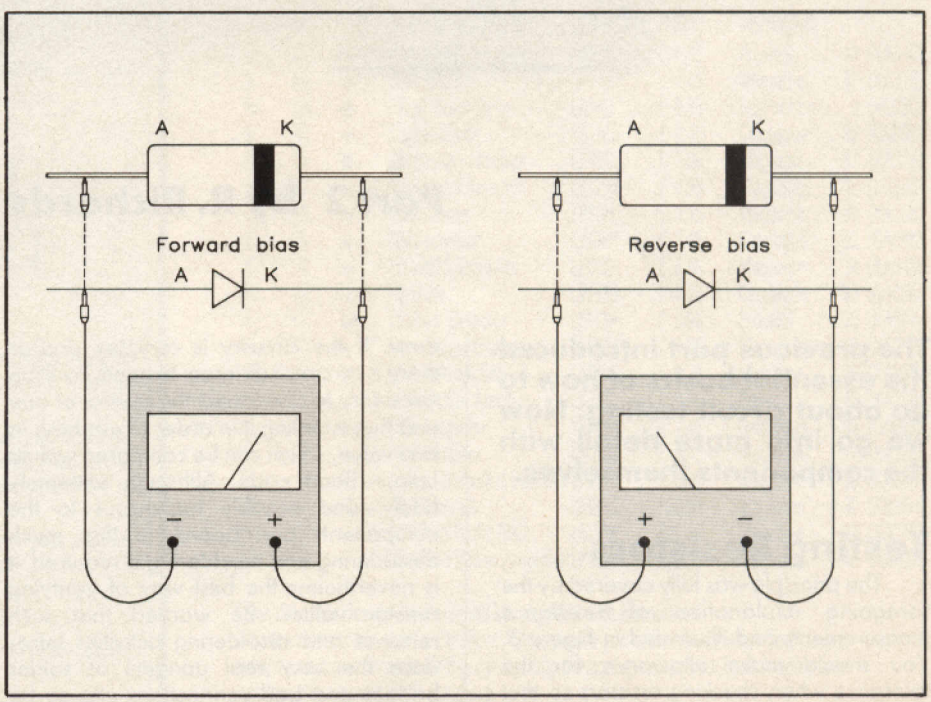


Figure 10. Testing a diode. Note – only range R x 1 and R x 100 used to test semiconductors.

ably close to the value stated by the designer – if you have such information of course. In any case the resistances of most inductors are rarely very high and, since they are made from windings of wire, you can look upon the testing of them as a form of continuity check. This will show whether the various connections follow through to other taps on the coil with which they should connect with no breaks, and that windings that are supposed to be isolated are in fact so. Small chokes are easiest to check, whereas some transformers are somewhat complex and require some sort of 'map', hopefully provided as part of a circuit diagram, to enable you to find your way around them.

While burnt windings – the evidence of a serious overload which destroyed inter-winding insulation if not the actual wire – are obvious, other misleading causes of a fault may stubbornly remain elusive during a continuity test. The best (and most frustrating until you get wise to the possibility) example is of the high voltage breakdown variety. In this case a high potential difference has perforated the internal insulation of a transformer, either between separate windings or between opposite ends of one high tension winding. The short circuit can only be completed by arcing the gap thus created, and which obviously doesn't show up on the meter because the instrument cannot duplicate the high voltage. Sealed away from outside view, such a fault causes a transformer to show all the signs of excellent health under interrogation by an ohmmeter, but obstinately refuse to work properly in use.

Testing Semiconductors

It is important before testing any semiconductor that the polarity of the meter leads is correct, due to the possibility of the negative terminal of the meter being connected to the positive pole of the internal battery as mentioned before. But how do you know? It can be proved by connecting the positive probe of the meter to the anode, and the negative probe to the cathode, of a known good diode with the lowest resistance range selected. If a low reading is obtained, then the *positive* terminal of the meter is connected to the *negative* pole of the battery, which, as indicated previously, is rare.

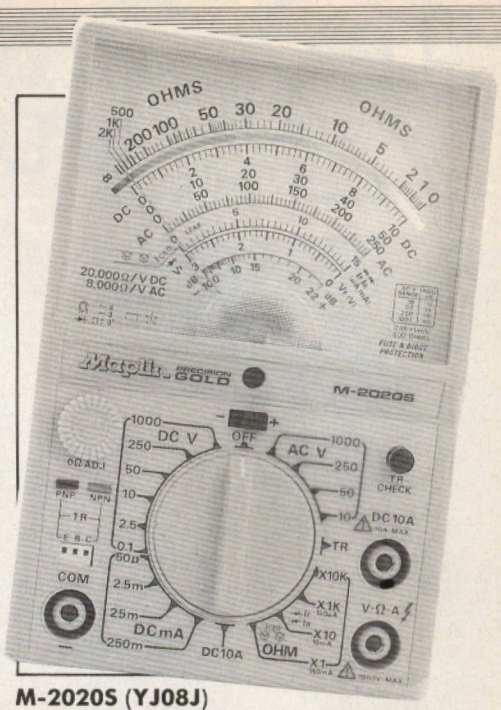
To avoid any misunderstanding, all the following semiconductor test procedures and examples will be shown with the assumption that the 'conventional' case applies, i.e. that the *negative* terminal of the meter is joined to the positive side of the battery, and that the test leads are not swapped, that is, black to '–' and red to '+' as normal. See Figure 10 which also shows the anode and cathode ends of the diode.

Testing Diodes

A diode will only pass conventional current in one direction, i.e. when the anode is more positive than the cathode. When testing a diode with an ohmmeter, connect the black probe to the anode and the red probe to the cathode, which with the meter switched to the resistance range R × 100, should give a low reading indicating correct forward conduction of the PN junction, see Figure 10a. When the probes are reversed a high reading should be obtained indicating reverse bias resistance is correct as shown in Figure 10b. If a low reading is obtained in *both* directions then the diode is short circuit in both directions and useless.

Because these two specific resistances are different but can vary, it is the ratio of one resistance to the other that is important. The ratio between the two resistances is called the front to back ratio (FB ratio), which should be more than 100:1 for power diodes and 1,000:1 for signal diodes. This ratio is calculated by dividing the reverse resistance by the forward resistance. For example a power diode with a reverse reading of 21,000Ω and a forward reading of 150Ω would have a ratio of 21,000 divided by 150 equals a ratio of 140:1.

However you should not take any such specific resistance readings literally, as they have no real meaning. The 'resistance' of a semiconductor junction varies with forward voltage drop, and so is said to be 'dynamic' (as opposed to 'static', or fixed). Hence the power diode showing 150Ω on the scale of the ohmmeter has a very small current flowing, whereas in use as a rectifier with a current flowing of 1A it is more like 1·1Ω.



M-2020S (YJ08J)
Analogue Moving Coil Multimeter, has a diode and transistor checker.

There are an increasing number of multimeters which include a special diode test facility. For instance the M-2020S has a special voltage scale for measuring the voltage drop across the diode between the probes, which in this case is calibrated for the X10 resistance range. Again the needle must be at zero first. 15mA is the forward test current for the diode, which

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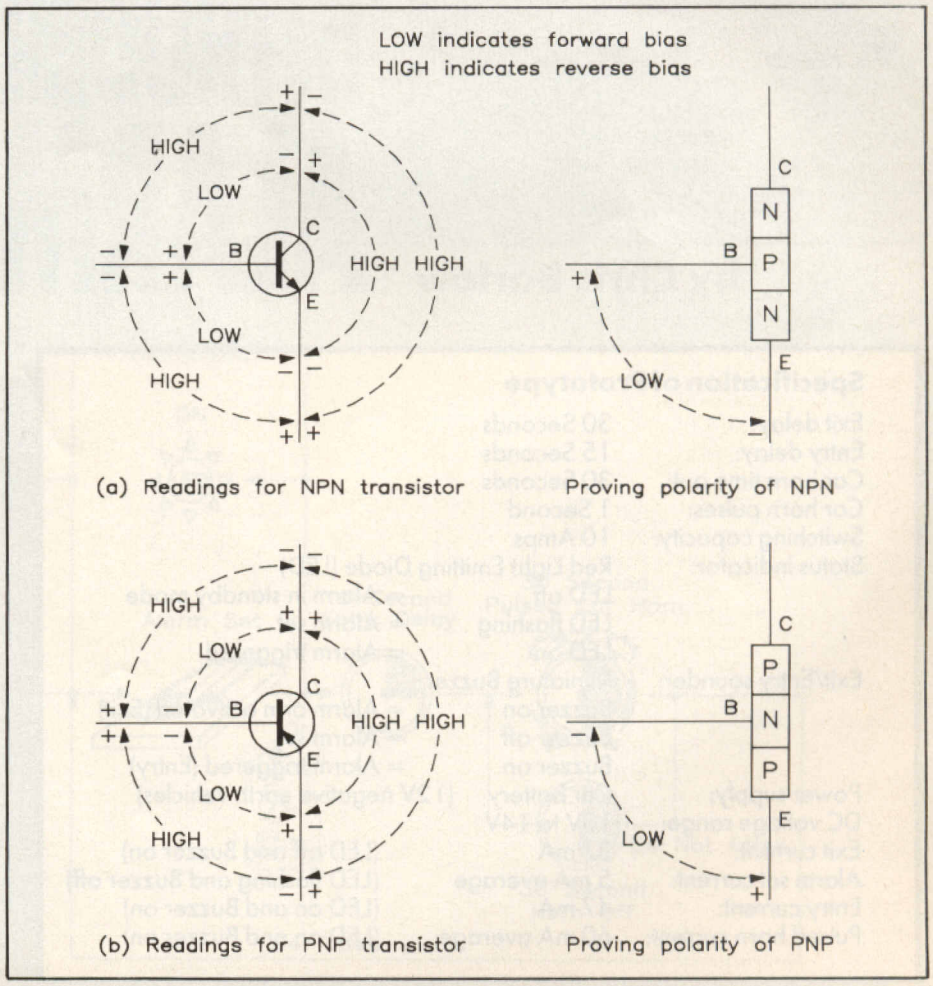
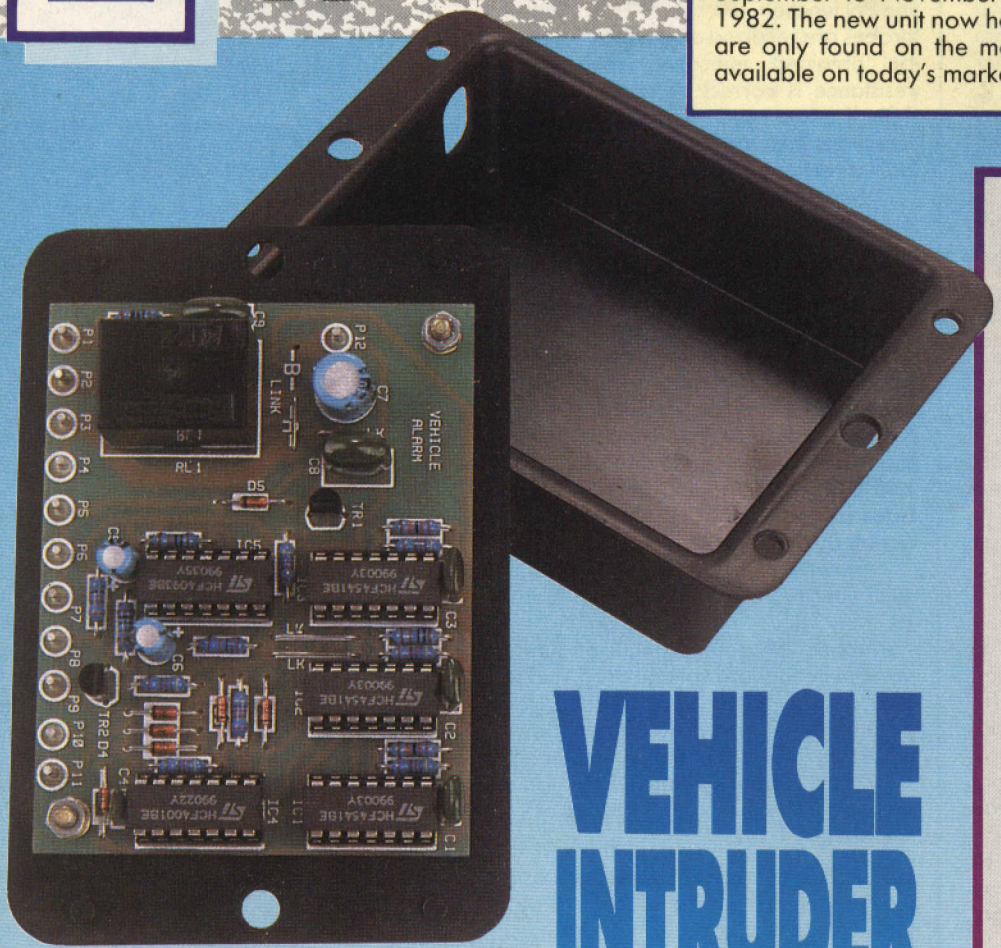


Figure 11. (a) Readings for NPN transistors. Proving polarity of NPN. (b) Reading for PNP transistor. Proving polarity of PNP.

2ND Time Around

Many projects from Maplin's range of kits have proved to be very popular over the years, but some of the older ones need updating and improving to meet the higher modern standards expected of them, and to use the current technology now available. This newly developed design supersedes the original Car Burglar Alarm Kit LW78K, which was first published in the September to November issue of the Maplin magazine in 1982. The new unit now has several additional features which are only found on the more expensive ready-made alarms available on today's market.



VEHICLE INTRUDER ALARM

by Chris Barlow

Original Car Burglar Alarm (Kit LW78K)

Features:

- ★ Exit Delay
- ★ Entry Delay
- ★ Car Horn Time Out
- ★ Compact Design
- ★ Inexpensive

New Vehicle Intruder Alarm (Kit LP65V)

Extended Features:

- ★ Exit Delay
- ★ Entry Delay
- ★ Status Indicator
- ★ Exit / Entry Sounder
- ★ Two Trigger Inputs
- ★ Pulsed Car Horn with Time Out
- ★ Large 10 Amp Switching Capacity
- ★ Function Options
- ★ Compact Design Retained
- ★ Same Super Low Price

Specification of Prototype

Exit delay:	30 Seconds	
Entry delay:	15 Seconds	
Car horn time out:	30 Seconds	
Car horn pulses:	1 Second	
Switching capacity:	10 Amps	
Status indicator:	Red Light Emitting Diode (LED)	
	LED off	= Alarm in standby mode
	LED flashing	= Alarm set
	LED on	= Alarm triggered
Exit/Entry sounder:	Miniature Buzzer	
	Buzzer on	= Alarm arm activated (Exit)
	Buzzer off	= Alarm set
	Buzzer on	= Alarm triggered (Entry)
Power supply:	Car battery	(12V negative earth vehicles)
DC voltage range:	10V to 14V	
Exit current:	37 mA	(LED off and Buzzer on)
Alarm set current:	5 mA average	(LED flashing and Buzzer off)
Entry current:	47 mA	(LED on and Buzzer on)
Pulsed horn current:	60 mA average	(LED on and Buzzer on)

Introduction

The need for an inexpensive but effective vehicle intruder alarm is becoming increasingly important as time passes. No alarm can offer complete protection against the determined professional thief, but it will act as a deterrent to the small-time thief or joyrider. This new improved version of Maplin's popular Car Alarm is, like most simple car alarms, triggered by the door switches used to operate the courtesy light(s). However, provision for an extra triggering device has been included, which could be for example an ultrasonic movement detector.

The vehicle intruder alarm will only work when fitted to a vehicle with a 12 volt negative earth system, which fortunately covers some 99% of all cars manufactured since the early 1960's.

The principle of operation is that the alarm is activated upon leaving your vehicle by the arming switch. This can take the form of a concealed push, toggle, or slide switch. However, a key switch will

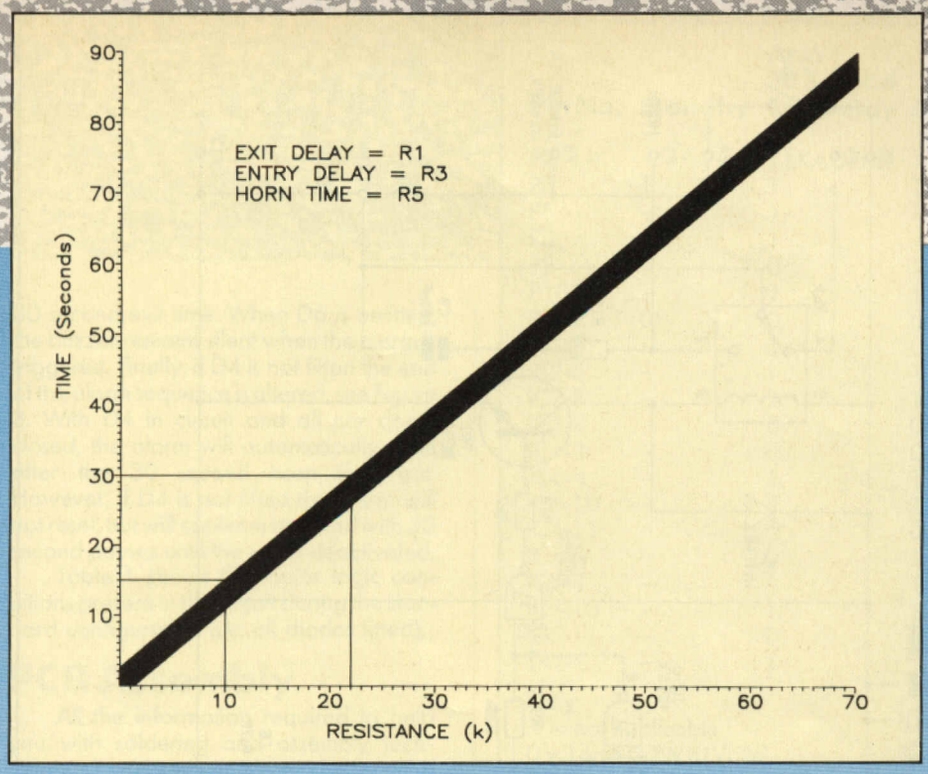


Figure 2. Timing chart.

offer a higher degree of security and does not have to be concealed. You then have 30 seconds to clear the vehicle and shut all the doors, and during this time a buzzer will be sounding. After this exit delay the alarm is ready to be triggered, and a flashing indicator can be used to show that the alarm is armed and act as an additional deterrent to the potential car thief. When one or more doors are opened the alarm is triggered; the indicator stays on and the buzzer sounds. You have a 15 second entry delay to deactivate the alarm before the horn begins to pulse on and off for 30 seconds. If a door is left open a continuous cycle comprising 15 seconds of silence followed by 30 seconds of pulsed horn sound will be repeated until the door is shut, or the alarm is deactivated. However, if the alarm is not deactivated but all the doors have been closed the unit will return to its ready mode with the indicator once again flashing waiting for the next intruder.

Circuit Description

A circuit diagram detailing the complete unit is shown in Figure 1. The timing and control of the sequence of events is governed by the logical functions of the following active devices:

Integrated Circuits:
IC1 = 4541BE programmable timer, 30 second exit delay.
IC2 = 4541BE programmable timer, 15 second entry delay.
IC3 = 4541BE programmable timer, 30 second horn time out.
IC4 A, B = 4001BE quad two-input NOR gate, alarm trigger.
IC4 C = 4001BE quad two input NOR gate, re-arm.
IC4 D = 4001BE quad two input NOR gate, horn active output.
IC5 A, B = 4093BE quad two input NAND schmitt trigger, LED flasher.
IC5 C, D = 4093BE quad two input NAND schmitt trigger, relay pulser.

Transistors: TR1 = BC548 NPN transistor, relay driver.
TR2 = BC548 NPN transistor, buzzer driver.

The timing and control of various events can be modified. To alter the time lapse of an event is a simple matter of fitting a different value resistor (R) for that particular programmable timer IC. Thus altering the value of R1 will affect the exit delay time, changing R3 alters the entry delay, and R5 fixes the horn time, see Figure 2. The only instance where it might become really necessary to alter the exit delay period is if your vehicle is fitted with a courtesy light extender unit. To accommodate this *increase* the exit delay timing resistor R1 to make the exit delay time slightly longer than the light switch-off time.

The sequence of the events is modified by omitting certain diodes. If D7 is left out, then the buzzer will not sound during the

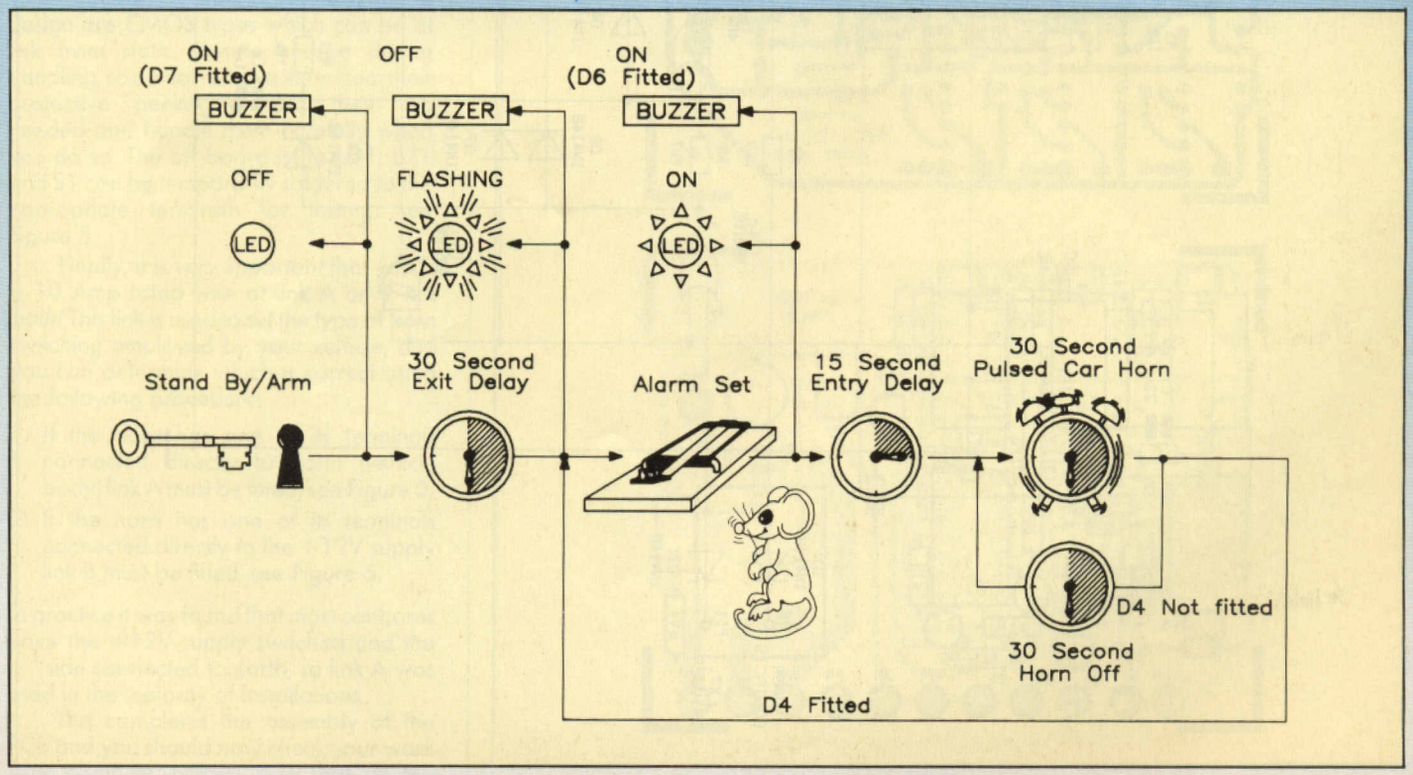


Figure 3. Alarm sequence and options.

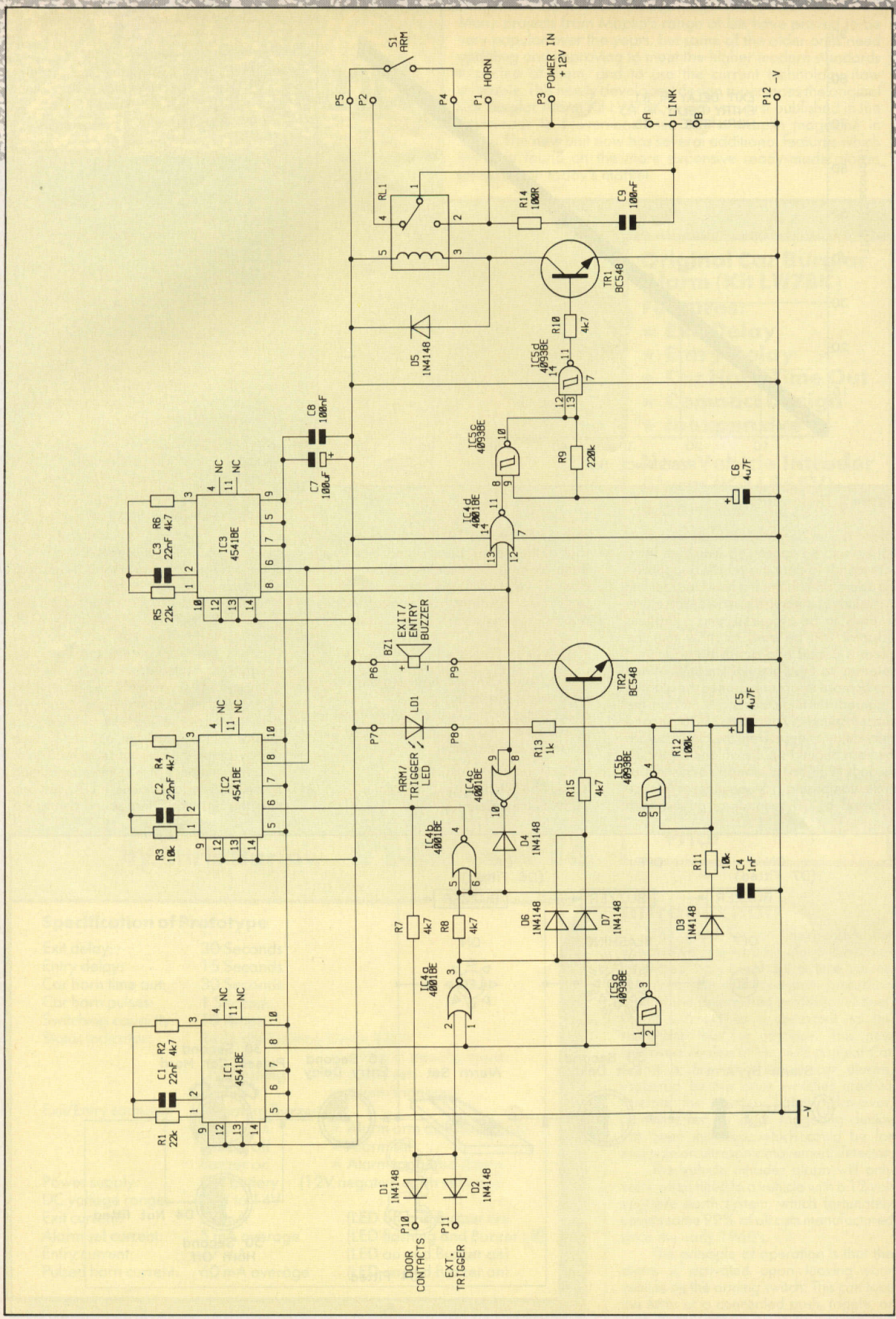


Figure 1. Circuit diagram.

30 second exit time. When D6 is omitted, the buzzer remains silent when the alarm is triggered. Finally, if D4 is not fitted the end of the alarm sequence is altered, see Figure 3. With D4 in circuit and all car doors closed, the alarm will automatically reset after the 30 second horn time out. However, if D4 is *not* fitted the alarm will not reset, but will continue to sound with 30 second pauses until the unit is deactivated.

Table 1 shows the major logic conditions present in the circuit during the standard configuration (i.e. all diodes fitted).

Pin No.	Standby	Arm + 30 Second Exit Delay	Alarm Set	Trigger + 15 Second Entry Delay	30 Second Pulsing Horn
P1	–	–	–	–	1 LKA 0 LKB P1
P2	–	1 LKA 0 LKB	1 LKA 0 LKB	1 LKA 0 LKB	1 LKA 0 LKB P1
P3	1	1	1	1	1
P5	–	1	1	1	1
P8	–	1	+12/10V P.5	+10V	+10V
P9	–	0	1	0	0
P10/11	–	1	1	0	0
P12	0	0	0	0	0
IC1-8	–	1	0	0	0
IC2-6	–	1	1	0	0
IC2-8	–	1	1	1	0
IC3-8	–	0	0	0	1 PE
IC4-3	–	0	0	1	1
IC4-4	–	1	1	0	0
IC4-10	–	1	1	1	0 PE
IC4-11	–	0	0	0	1
IC5-3	–	0	1	1	1
IC5-4	–	1	1/0 P.5	0	0
IC5-10	–	1	1	1	1/0 P1
IC5-11	–	0	0	0	0/1 P1
TR1-C	–	1	1	1	1/0 P1

Key

– = not applicable
0 = Logic LOW (0 Volts)
1 = Logic HIGH (+12 Volts)
0/1 = LOW going HIGH
1/0 = HIGH going LOW
LKA = Link A on PCB (10 Amps)
LKB = Link B on PCB (10 Amps)
P1 = Pulsing every second
P5 = Pulsing every half second
PE = Pulse at end of time period
IC1-11 = IC pin number
TR1-C = Transistor collector

Table 1. Logic conditions.

PCB Assembly

All the information required to help you with soldering and assembly techniques, should you need it, can be found in the Constructors' Guide included in the kit (also separately available as stock code XH79L). Removal of a misplaced component can be fairly difficult without causing too much damage, so *please* double-check each component type, value and its polarity where appropriate, before soldering! The printed circuit board (PCB) has a legend to assist you in correctly positioning each item, see Figure 4. Install, solder and trim the excess leads from all the components commencing with the resistors and capacitors, and finishing with the IC sockets, diodes and transistors last. Only after all other components have been fitted do you then carefully insert the relevant ICs into their sockets making sure to correctly align the pin number 1 marker at one end of each DIL package with the white block on the legend. All the ICs in this design are CMOS types which can be at risk from static electric charge during handling, so do not remove them from their protective packaging until they are needed and handle them carefully when you do so. The off-board items LD1, BZ1 and S1 can be temporarily soldered to the appropriate terminals for testing, see Figure 5.

Finally, it is *very important* that you fit a 10 Amp rated wire at link A or B, *not both!* This link is used to set the type of horn switching employed by your vehicle, and you can determine which is correct using the following procedure:

1. If the horn has one of its terminals connected directly to earth (vehicle body) link A must be fitted, see Figure 5.
2. If the horn has one of its terminals connected directly to the +12V supply link B must be fitted, see Figure 6.

In practice it was found that most car horns have the +12V supply switched and the '–' side connected to earth, so link A was used in the majority of installations.

This completes the assembly of the PCB and you should now check your work very carefully making sure that all the solder joints are sound. It is also very

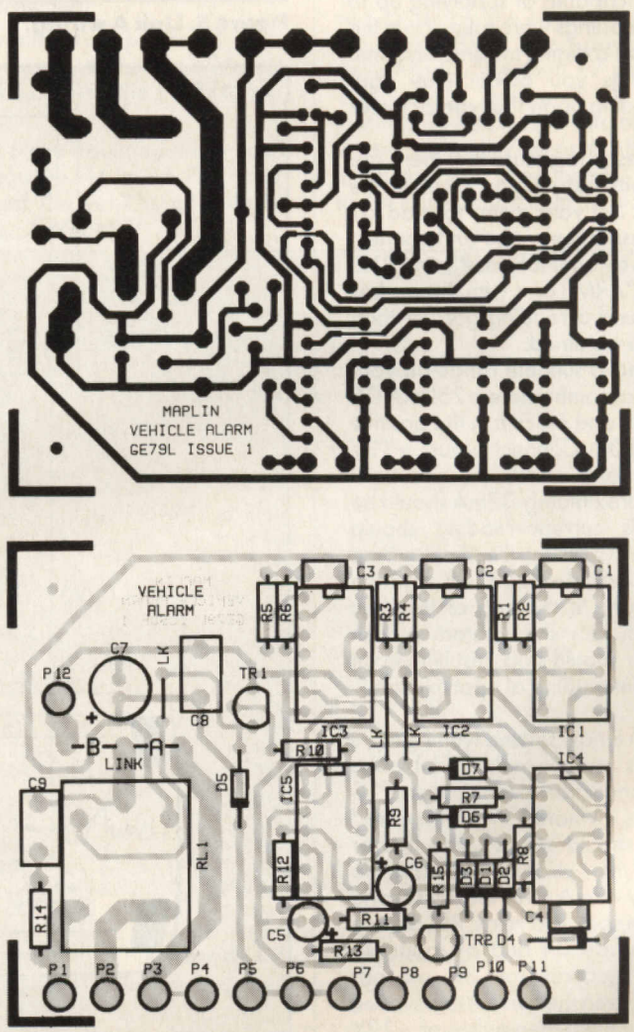
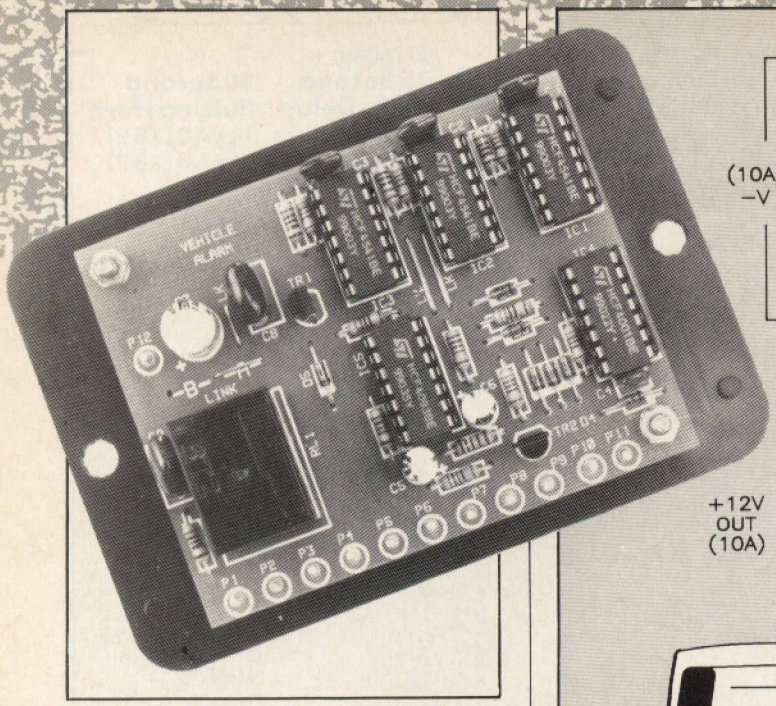


Figure 4. PCB Legend.



Completed PCB

important that the solder side of the circuit board doesn't have any trimmed component leads standing proud by more than 2mm, as this may result in a short circuit.

Testing

All the tests can be made with a minimum of equipment. You will need a multimeter and a regulated +12V DC power supply capable of supplying up to 250mA. The readings were taken from the prototype using a digital multimeter; some of the readings you obtain may vary slightly depending upon the type of meter employed.

The first test is to ensure that there are no short circuits before you connect the power supply. Set your meter to read kΩ on its 20kΩ resistance range and connect the test probes to terminal pins P3 and P12. Switch on S1 ('ARM') and with the probes either way round a reading greater than 4kΩ should be obtained.

Next, select a suitable range on your meter that will accommodate a 250mA DC current reading and place it in the positive power line (P3). Connect your +12V power supply and switch on, a current reading of approximately 37mA should be observed. This current reading should continue for the 30 second exit delay time with the LED indicator, LD1, off and the buzzer, BZ1, on. At the end of this time period the indicator should start to flash and the buzzer should stop, resulting in an average current reading of approximately 5mA.

The alarm is now set and waiting to be triggered. This can be achieved by the momentary connection of terminal pin P10 or P11 to P12 (−V earth). When triggered the indicator should stay on, the buzzer sound and the current increase to approximately 47mA over the 15 second entry delay period. The relay RL1 should then start to pulse on and off approximately every second for 30 seconds increasing the average current to 60mA. If link A has been fitted then pulses of +12V should appear on P1, while link B produces momentary grounding. At the end of this

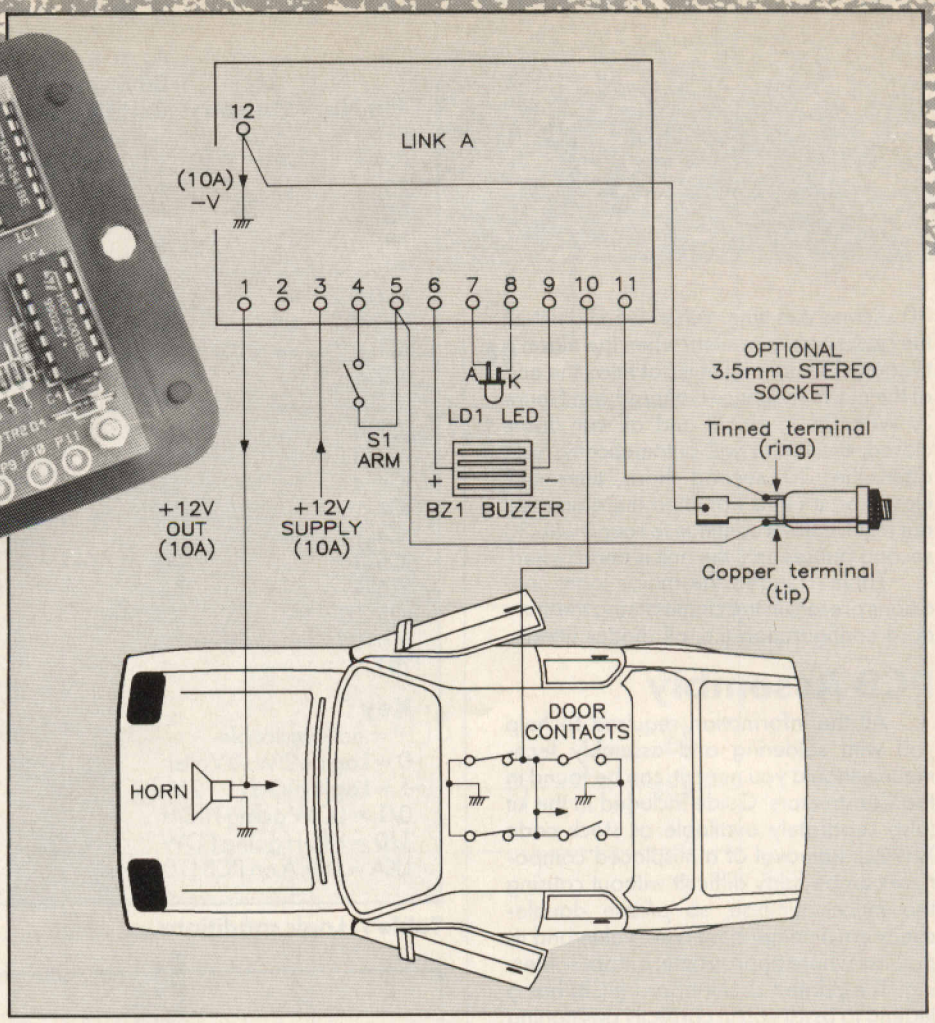


Figure 5. Link A wiring.

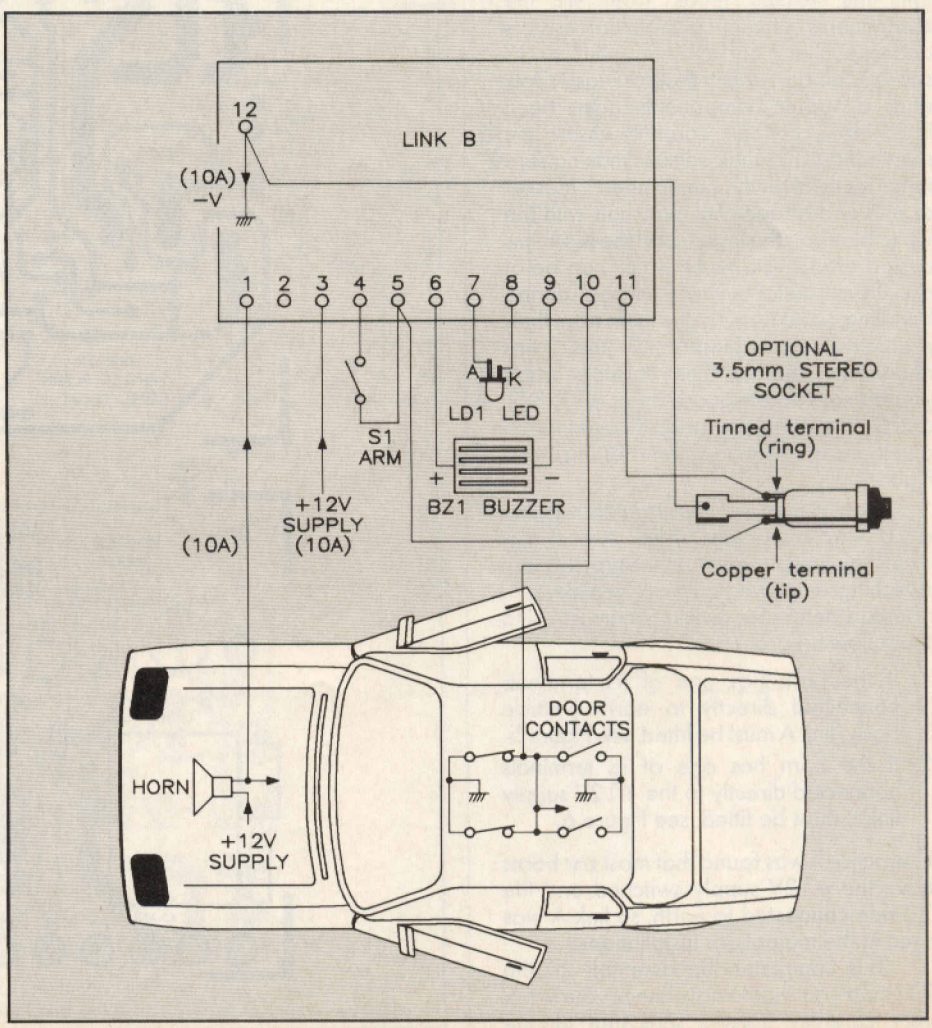
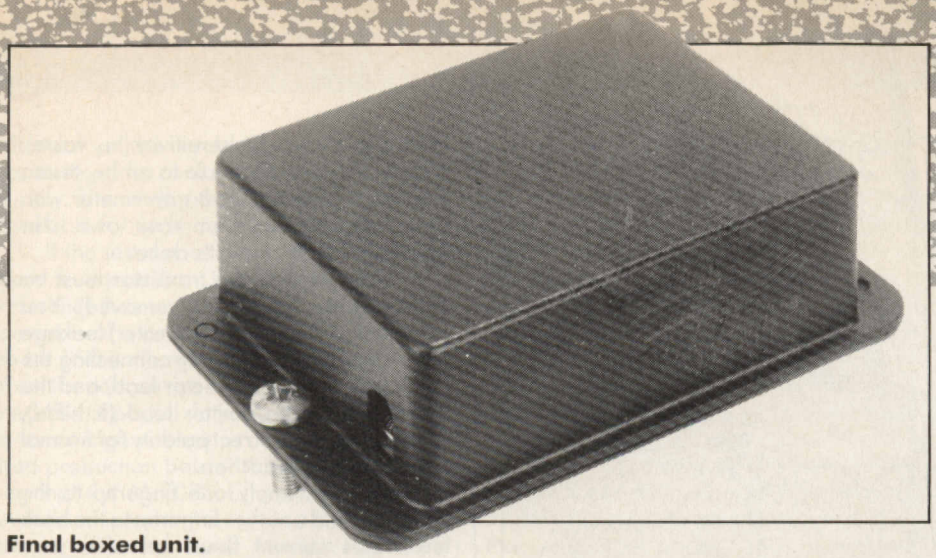


Figure 6. Link B wiring.



Final boxed unit.

period the alarm should return to its ready mode with its indicator flashing and the average current back at 5mA.

This completes the testing of the unit. You should now remove your DC power supply and multimeter. If you have experienced any difficulties in obtaining the correct results the circuit logic conditions shown in Table 1 should be of some help in tracing the fault.

Installation and Wiring

Before the completed circuit board is installed into a vehicle it must first be enclosed in a non-conductive protective housing. The PCB is designed to fit into a small plastic box and base type 2 (stock code YN36P). It has a loose fitting base which is secured when the box is fixed to a panel or bulkhead. Alternatively, the base may be bolted to the box if the unit is to be left floating amongst the general interior wiring of your vehicle.

The additional off board components, arming switch S1, LED indicator LD1 and buzzer BZ1 are wired to the alarm using coloured general purpose hook-up wire (7/0·2). If you are not using a key switch S1 must be mounted in a concealed position, e.g. fitted under the dashboard or in the glove compartment etc. However, the opposite is true when positioning the LED indicator, this needs to be seen if it is to act as an additional deterrent. The buzzer should be placed so that it can be clearly heard by you and your passengers.

Make sure that you have the correct link (A or B) fitted and with reference to Figure 5 or 6 proceed as follows:

1. Ensure that the arming switch S1 is OFF (Alarm deactivated).
2. Find a convenient fuse-protected positive supply source, and using 10A *red* insulated wire connect the +12V to pin P3.
3. Using 10A *black* insulated wire, connect the negative return on P12 to a metal part of the vehicle, or directly back to the negative terminal of the battery.
4. Double check which horn wiring is correct for your type of vehicle, see Figures 5 and 6. Then connect a 10A insulated wire from P1 to the horn as shown.
5. Using hook-up wire connect the trigger input P10 to the courtesy light door contacts.

This completes the basic installation. The unit can now be armed and tested ready for use. However, there are some additional options that can be fitted to the alarm system, the first of which is the addition of a 3·5mm stereo jack socket, supplying a switched +12V to a remote triggering device such as an ultrasonic movement detector. When triggered, the output of this can be taken via the jack socket back to P11 which has the same effect as opening one of the doors.

The other addition should not be considered unless you have a good working knowledge of your vehicle's ignition system. It is possible to interrupt this and so disable the engine, thus preventing the vehicle from being driven off. If you have fitted link A then P2 will produce a 10A +12V feed until the horn starts pulsing, at which time this output will be interrupted every second. Alternatively, if link B has been fitted then P2 is connected to the earth return until the horn starts up.

VEHICLE ALARM PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,5	22k	2	(M22K)
R2,4,6,7,8, 10,15	4k7	7	(M4K7)
R3,11	10k	2	(M10K)
R9	220k	1	(M220K)
R12	100k	1	(M100K)
R13	1k	1	(M1K)
R14	100Ω	1	(M100R)
CAPACITORS			
C1,2,3	Mylar 22nF	3	(WW19V)
C4	Mylar 1nF	1	(WW15R)
C5,6	PC Electrolytic 4μ7F 63V	2	(FF03D)
C7	PC Electrolytic 100μF 25V	1	(FF11M)
C8,9	Mylar 100nF	2	(WW21X)
SEMICONDUCTORS			
IC1,2,3	4541BE	3	(QQ47B)
IC4	4001BE	1	(QX01B)
IC5	4093BE	1	(QW53H)
TR1,2	BC548	2	(QB73Q)
D1-7	1N4148	7	(QL80B)
LD1	LED Red	1	(WL27E)
MISCELLANEOUS			
RL1	12V/10A Min Relay	1	(JM67X)
P1-12	Pin 2141	1 Pkt	(FL21X)
	Box and Base Type 2	1	(YN36P)
	DIL Socket 14-pin	5	(BL18U)
	Buzzer 12V	1	(FL40T)
	Table Light Switch	1	(FH94C)
	Vehicle Alarm PCB	1	(GE79L)
	Constructors' Guide	1	(XH79L)
	Vehicle Alarm Leaflet	1	(XK62S)
	Posiscrew M3 10mm	1 Pkt	(LR57M)
	Steel Nut M3	1 Pkt	(JD61R)
	Steel Washer M3	1 Pkt	(JD76H)
	Isoshake M3	1 Pkt	(BF44X)
OPTIONAL (not in kit)			
	Min Key Switch	1	(FE44X)
	Wire 3202 Black	1	(XR32K)
	Wire 3202 Red	1	(XR36P)
	16/0·2 Wire 10M Green	1	(FA29G)
	16/0·2 Wire 10M Orange	1	(FA31J)
	16/0·2 Wire 10M White	1	(FA35Q)
	16/0·2 Wire 10M Yellow	1	(FA36P)
	LED Clip Convex 5mm	1	(UK14Q)
	Piezo Electronic Siren	1	(YP11M)
	Stereo 3·5mm Ch Jk Skt	1	(FK03D)
	Alarm Sticker	1	(JR91Y)
	Self-Tap No.8 × ½in	1 Pkt	(BF69A)
	Isobolt M4 12mm	1 Pkt	(BF49D)
	Isonut M4	1 Pkt	(BF57M)
	Spring Washer M4	1 Pkt	(JD95D)

The above items, excluding Optional, are available as a kit:
Order As LP65V (Vehicle Alarm Kit) Price £9.95
The following item is also available separately but not shown in our 1991 catalogue:
Vehicle Alarm PCB **Order As GE79L Price £2.95**

Circuit Testing Continued from page 55

should show 0·7V on the diode test scale if a silicon type. The next range up, X1K, can be used for reverse testing for which 150μA is available.

Testing Bipolar Transistors

The continuity of a transistor can be tested in an identical way. Since both the base/emitter (BE) and collector/base (CB) junctions are effectively diodes, then the black probe of the meter can be connected to the base and the red probe to the emitter leads, which should produce a low reading indicating normal forward bias resistance of the BE junction. Upon moving the red probe to the collector, the meter should again show a low reading indicating correct forward bias resistance of the CB junction.

Reversing the probes, with *red* to base and *black* to emitter, or *black* to collector, should show a high reading proving adequate reverse bias resistance of the BE junction in the first case, and the CB junction in the second case. A high reading in *both* directions would indicate an open circuit of the junction, while a low reading in both directions would indicate a short circuit of the junction, and the transistor is unserviceable.

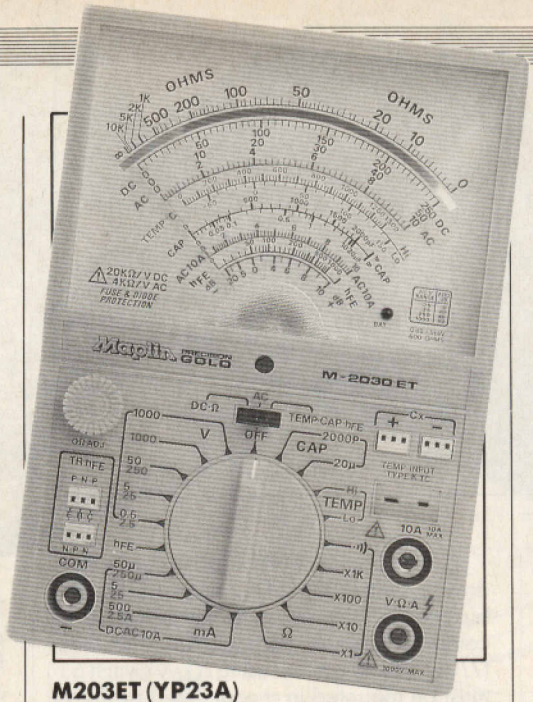
Some idea of I_{CE} (collector leakage current) can be made by connecting the black probe to the collector lead, and the red probe to the emitter lead. A high reading will indicate little if any leakage current, which is correct. In fact this should be the case in both directions (probes reversed), and a low reading usually means that the device has been damaged and is useless. Again the M-2020S has a special transistor test facility, whereby not only can correct transistor operation be verified, but that the type can be determined as NPN or PNP. This still doesn't alter the fact that you have to find out first which transistor leads are the base, emitter and collector.

The Unknown

In the absence of such an instrument, given that the black probe is plus and the red probe is minus because of the ohmmeter's battery polarity, then it can then be deduced that the device tested in the above example is a NPN type, indicated by the low forward bias resistance when the black probe was connected to the base and the red to the emitter. In this way it is easy to determine which type, NPN or PNP, is an unknown device. See Figure 11a.

Testing PNP Transistors

The junctions of PNP transistors are exactly the reverse in polarity in comparison to the NPN type. Exactly the same tests can be done except that in all cases the probes are reversed, i.e. for 'black' read 'red' and vice versa. See Figure 11b. The transistor need not be removed from a PCB



M203ET (YP23A)
Analogue Moving Coil Multimeter, has capacitance ranges.

for these sorts of tests, but, as mentioned earlier, peripheral components, especially resistors, can distort the results, so it may be necessary to isolate (remove) the device from the board. It should be mentioned that modern silicon transistors are so good these days that any reverse leakage tests should result in *infinite resistance* (pointer not moving at all) when carried out on a transistor in isolation.

More than this, it *is* possible to find out whether the device is capable of current amplification even to the point of getting a fairly good idea of its sensitivity (h_{FE} value). It does not need recourse to an h_{FE} tester, but can be done with an ohmmeter with some extra help from your own skin resistance. This is how it's done.

To begin with the transistor must be isolated from the circuit (removed). You perform the CE (collector/emitter) leakage test as described above by connecting the black probe to the collector lead, and the red probe to the emitter lead (if NPN), which is also the correct polarity for normal transistor CE conduction.

You then apply one fingertip to the collector, and another fingertip to the base lead. Bias current flows between your fingers into the base and is amplified by the transistor. Usually it only works while the ohmmeter is on its highest resistance range, because the current passed by the transistor is still quite tiny. However it should be possible to move the pointer to a lower resistance reading in this way, and cause it to vary in sympathy with finger pressure.

This at least proves that the transistor is operational, though the method is too crude to make accurate comparisons, but some verification of a device is possible. If a 'reference' transistor is to hand with a known h_{FE}, then the device under test may be compared with it to see if its h_{FE} is approximately the same, worse, or better. For example, a reference device has an h_{FE} of 100 – 150, registering about 20kΩ on the scale. The test device shows 60kΩ for an identical test, meaning that its current gain is poorer. Making these tests truly

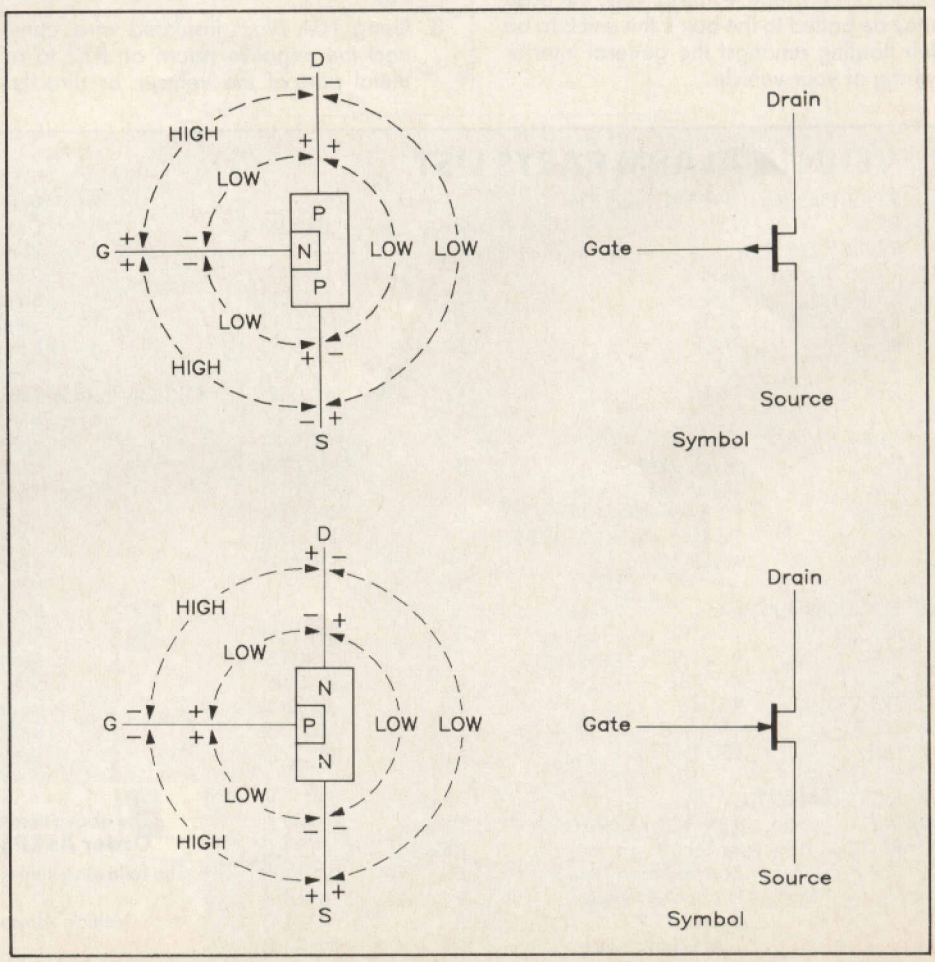


Figure 12. (a) P channel depletion FET. (b) N channel depletion FET.

identical is the problem, because skin resistivity varies as does ohmmeter battery supply. This is why the reference must be available for an immediate comparison.

If the test device shows 60kΩ then its gain is worse than the reference. If the reference has an h_{FE} of 150, and the test device is of a type which is also supposed to be 150 (with reference to data tables), then the test device is below spec, either because of partial damage caused by heat stress or high voltage or current, or from a bad production batch. It's worth mentioning that the M-2030 ET multimeter does include a proper transistor tester, compared with the basic checker of the M-2020S, and which actually registers current gains up to 1,000 h_{FE}.

Junction Gate Field Effect Transistors

These, abbreviated to JUGFET (as opposed to a MOSFET), can be tested with the multimeter switched to a suitable resistance range by measuring the resistance of both the PN junction and the channel path. A good FET would give the results as illustrated in Figure 12a. Note that Figure 12a illustrates a P channel FET where the reading between the drain and gate terminals, with the black probe to drain, would give a low reading indicating forward bias of the PN junction. Reversing the polarity should give a high reading, indicating the reverse bias resistance of the junction. A similar effect would also be obtained by applying black to source and red to gate, again indicating forward bias of the PN junction, and by reversing the polarity, a high reverse resistance of the PN junction. This is because the device is not fussy whether the drain or source is used in the test of the junction.

A resistance test of the channel between drain and source should show a low reading in both directions. Testing a N channel FET is exactly the same except that the probes are reversed (black to gate etc.). See Figure 12b.

A 'dynamic' sort of test, as can be done with a bipolar device using finger resistance, is a little more awkward with a FET however, but not impossible. With a spare PP3 battery and a couple of test leads to hand, the two probes can be attached across drain and source to measure the channel resistance. Then upon applying the battery voltage across the source and gate – ensuring however that the PN junction is *reversed* – the channel resistance should increase appreciably as the gate charge closes down the channel. It may even be possible to see, after the battery is disconnected, the resistance fall slowly as the gate charge leaks away slowly. It can be forced to discharge quickly by shorting the gate and source terminals.

MOSFETs however are much more difficult to examine, especially if they are of a type susceptible to static damage, such as the very early ones. This makes the handling of them very risky.

Where the JUGFET used a reversed diode junction to create an electric charge across the junction, the electric field of which resists electron flow through the channel, the MOSFET on the other hand has a gate structure resembling a microscopic capacitor. There is literally a very thin dielectric, or insulating film, between the gate electrode and the channel. This is why MOSFETs (and in fact any IC which incorporates them, such as CMOS) are at risk from excessive static electric charge, because such a high charge is perfectly capable of perforating the thin insulating film. Of course, if the device is suspect you may well have nothing to lose, and, since modern MOSFETs include a protection scheme for the gate, you may be able to confirm whether or not the device is sound, and if it is, may even be able to solder it back where it came from undamaged, or not.

Basically the resistance between a MOSFET's channel and gate should be infinity in either direction, because the main purpose of a MOSFET is to provide very high input impedances, perhaps more than can be achieved by a JUGFET. A low resistance reading in this case very definitely means that the device is effectively destroyed.

Controlled Silicon Rectifier (CSR)

The CSR is a four layer semiconductor with three terminals, the Anode, Cathode and Gate, as shown in Figure 13. A resistance test made from anode to cathode should give a high reading in *both* directions and the same effect will be found by testing from anode to gate. Any low reading in the above test would indicate a faulty CSR. Testing from gate to cathode with black to gate will give a low reading indicating forward bias of the GK PN junction. A slightly higher reading would be obtained by reversing the polarity. As a rule of thumb while performing resistance tests on semiconductor devices, it is suggested that a low reading may be taken as something below 200Ω, and a high reading something above 2 megohms (2MΩ).

To Conclude

Voltage and current tests must be made with the power switched on, and every precaution must be taken to avoid shocks. Large capacitors can hold a high voltage charge for long periods after power-down due to dielectric absorption, so beware of these items and make sure they are discharged before handling. Resistance tests should always be made with the power switched *off* and the circuit tested to make sure that it is free of short circuits before switching on the power. It is also worth noting that any reading within 10% is generally acceptable, which makes allowance for resistance and meter tolerances. This article has attempted to show the basic principles confined to testing with a multimeter using 'go/no-go' methodology which, under normal conditions, is all that is required to clear the fault. Complex defects require other tests and other equipment which is beyond the scope of this article.

ICs are impossible to check on their own without a special test 'rig' or made-up test circuit, so when examining them it is much better to leave them in the circuit in which they are being used. Only after ensuring that the remainder of the circuit is operational can the IC be checked by examining pin voltages etc., but in all events this will mean *nothing* without data to hand about the IC itself, how it operates and what it does. If you know and recognise the device's number – op-amps, for instance, are not too complicated to understand and test – then so much the better, otherwise you have no chance of knowing whether what you are seeing is correct or not.

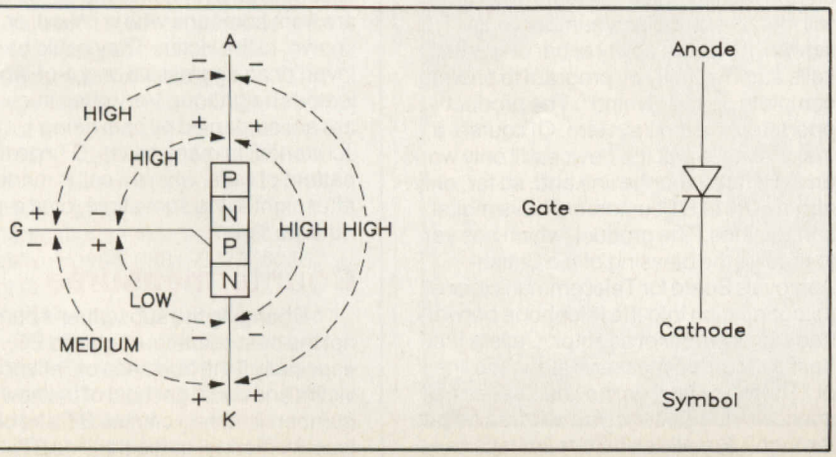


Figure 13. Thyristor or CSR.

And Lastly

1. Safety first – for yourself, your test equipment and not least the circuit itself under test.
2. A circuit diagram is essential. Also have any other relevant information, specifications and manufacturer's data to hand if possible.
3. Keep notes on paper which will aid a process of elimination.
4. Don't assume anything.
5. Remember that all readings will have a degree of error, depending on the accuracy of the instrument.

TACKLING NUISANCE OR OBSCENE TELEPHONE CALLS

by Alan Simpson

Each year, BT receive over 200,000 calls for help. Not, in these cases, from frustrated subscribers trying to phone a Maidenhead number in the morning, or complaints from users discovering that their Swedish au pair has been 'phoning home every day in prime time.

No! These calls for help come from troubled and worried users, who have been on the receiving end of obscene calls. In this respect, as BT makes clear, even a silent call can be a major cause for concern.

With some individuals being subjected to hundreds of nuisance or obscene telephone calls a year, the telecoms authority OFTEL has now issued the results of their widespread survey conducted last year. The survey suggested that women had received in the order of 20 million obscene calls in the previous twelve months, while men had received around five million. But the report also found, rather surprisingly, that around 10% of those who had received obscene calls knew the caller personally in at least some of their calls. In fact only about 15% of respondents receiving calls reported them to British Telecom.

All too often in fact, victims of nuisance or malicious calls turn to an array of self-help equipment, rather than report the problem to BT. Such products as the 'Inquisitor', marketed by Ampcrest Computers at about £150, offers "a unique technological breakthrough that will identify the caller's number on its screen. It has the ability to bar unwanted calls automatically by program to provide complete peace of mind". The product operates on a tone system. Of course, a major snag is that the device will only work on a digital exchange line and, so far, only about 60% of BT customers have digital connections. The product, which has yet to receive the blessing of the British Approvals Board for Telecommunications, for connection into the telephone network, has a phone socket adaptor. Callers first hear a recorded message along the lines of "There is a fault on the line, please dial your own number and you will then be put through". For all its obvious limitations – will the obscene caller really key in his phone number? – the product could provide reassurance to many subscribers. But, as 'Electronics Weekly' points out, "a cheaper and more caller-friendly solution could be the answer-phone. This will deter many malicious callers or at least save up the calls so that the victim is not disturbed every few minutes".

Dirty Raincoat Brigade

In the course of their own survey of some 10,000 households, 25% of women and 19% of men reported that someone in their household, during the past year, had been on the receiving end of an obscene call. More interestingly, over 70% of those reporting a problem had not taken any further action.

To help identify the problem, BT found that 41% of calls, triggered by the so-called 'Dirty Raincoat Brigade', were silent, while 18% had a sexual content. BT believes that the silent calls are more intimidating than a voice call, particularly late at night of early in the morning. BT suspect that over half of the calls made are from someone who is linked, or known, to the victim. They could be a jilted lover, or an aggressive or out-of-work jealous neighbour. Very often such calls are accompanied by cars being scratched. In many cases, BT can trace a pattern of calls, where a call is made night after night at the same time, or at a 'preset random' time.

Countermeasures

Changing the subscriber's number is not the best solution, suggests BT, especially if the nuisance caller knows the victim and could get hold of the new number. It merely causes BT a lot of inconvenience, particularly as BT engineering cannot reissue the number.

To rub salt into the wound, BT will charge you nearly £30 to have your telephone number changed, together with the advice that the subscriber should have their new number listed ex-directory!

Although the nuisance calls are anticipated to generate at least £1m for BT, the corporation spends over £5m on countermeasures. This includes a free national helpline service on 0800 666 700, where victims receive recorded advice on how to deal with obscene calls. There is also a free leaflet, 'Tackling the problem of malicious phone calls', available, giving detailed, practical advice and an outline of the legal action which can be taken against callers.

BT also offers service interception where the operator will intercept all incoming calls for a limited period of time. Only those known callers will be put through. However, the system does tend to put off genuine as well as malicious callers. Even more dramatic is the barring of all incoming calls. Although, given the steady introduction of digital exchanges, call tracing is feasible, it will only be carried out by BT at the direct request of the police, and in any case this is only effective where a call is digital from end to end, or stays within the one exchange. Where an analogue exchange is involved, an engineer has to be present to observe which relays are switching, a somewhat impractical and costly exercise.

There is no one answer to the problem. Says BT "It is a very complicated issue. In fact 58% of our customers only want advice and are reluctant to seek the help of the police or the Courts. It is our problem and also that of society at large". But anyone seeking help is advised to phone the BT national helpline without delay.

Premium Rate Services Call-Barring

Reacting to public disquiet, as OFTEL points out, BT has now introduced a call-barring service on premium rate lines. The service, which is free, is only available to customers on digital exchanges, approximately half of BT's exchange lines at present. Customers opting for the service will have calls from all premium rate lines, accessible from BT's network, barred, including those of Mercury, Kingston and Racal Communications – that is, all numbers with prefixes 0898, 0881, 0077, 0066, 0836 or 0839.

The service is non selective since it operates at the exchange level, and so also affects the information type of services, e.g. sports scores and Stock Exchange information, as well as entertainment type services such as interactive games and most Chatlines.

DIRECTORY ENQUIRY CHARGES – DIY ALTERNATIVES

by Alan Simpson

The bad news was that, earlier this year, BT decided to charge callers for its Directory Enquiry Service. The less promoted good news was that at the same time, the cost of telephone calls was reduced by an average of 6%. This means that typical residential customers who do not use directory enquiries will see a reduction of over £4 per year in their bills.

The even less promoted good news is that directory enquiries made from public call boxes and most private payphones remain free, particularly handy if your home or office is close to a public call box. Meanwhile, a surge in the demand for payphones is well on the cards. As the leading telecomms industry digest 'Telecomms Regulation Review' (TRR) makes clear, the rental and call charges are the same as for an ordinary line: the only extra expense is the one-off cost of an approved payphone.

However, as TRR points out, BT requires that payphones should make at least three 'effective connections' (i.e. ordinary, charged telephone calls) for every call to Directory Enquiry (DQ). In passing, TRR believes that this raises the interesting question of whether a call routed via Mercury would constitute an 'effective connection'. If so, then customers of Mercury's 2,200 and 2,300 services could use BT for free DQs, but then route their actual calls to Mercury by dialling 131 (a facility now available on many BT exchanges). This, says TRR editor Dermod Quirke, would obviously be unfair to BT, but if it was not permitted, BT would probably be in breach of the Interconnect Agreement imposed by Oftel.

These bizarre anomalies show, says TRR, just how little thought has gone into the planning of DQ charging. "In their eagerness to abolish cross-subsidised calls, BT and Oftel have failed to distinguish between genuine enquirers and credit-checking agencies, so that in practice the new system forces the former to subsidise the latter. And the provision of free DQs to payphone users – a cosmetic device with no logical justification – enables ingenious users to avoid not only BT's 38p charge, but also Mercury's 50p".

But whether, in practice, subscribers will 'freeload' by seeking out a local payphone or call box remains to be seen. Especially as these free facilities are not widely promoted. As usual, Oftel have overlooked the simple DQ charging formula. BT subscriber lines are already designated either business or domestic. How much easier for all concerned if the DQ charge only applied to business users, and not to Aunt Kim trying to find out the 'phone number of her long lost sister Kate, living somewhere in the Cotswolds.

Database Directories on Line

In any case, business and other heavy number information users have a variety of alternative, cost effective and time saving options, including Phone

BT's Malicious Calls Bureau has been set up to offer practical help and advice to victims of nuisance and obscene phone calls.

Base and Phone Disc. Phone Base, as the TRR explains, is BT's online directory database, offering a do-it-yourself alternative to the operator-assisted directory enquiry service. Phone Base subscribers can access the database direct, and search for numbers and address information. There is no subscription fee, but registration is required. BT provide registered users with the telephone number of the service, and a personal access code for the system. Calls are charged at National (b1) rates; which is just over 5p per minute cheap rate. Joining this particular club is easy, the only requirements being an IBM or IBM compatible PC, a modem and suitable comms software.

Alternatively Phone Disc contains similar directory listing information on a single compact disk. Since both these products were unveiled some six months ago, British Telecom has made significant enhancements to them, and the services are proving useful for such organisations as mail order companies, as a popular substitute to paying 19p per address, allowing for the fact that your 38p fee allows you to access two numbers.

Also seeing a resurgence of interest is the national, dial-up access, Electronic Yellow Pages (EYP) service from BT. This is a fully up-to-date and fully comprehensive source of national classified information. Businesses across the UK are available on EYP, from a builder in Birmingham to a restaurant in Folkestone, 24 hours a day, 7 days a week.

Joining this particular club requires a Videotex or VT100 terminal, and there are no EYP subscription or usage charges. To make access to the service as simple as possible, EYP has one national dial-up number, 0345 444 444. This number will automatically operate at your modem speed (up to 2400 baud), and most common parity settings. A key point of EYP is that calls are at local phone call costs.

Don't 'Phone Home ET – Unless You Already Know the Number

Meanwhile, the Office of Telecommunications (Oftel) reminds BT customers – such as Aunt Kim – that a charge is made for searching for the requested number, and this charge is still payable even if BT is unable to supply the number through no fault of its own (e.g. Sister Kate's number happens to be listed as ex-directory). However, BT's licence requires it to provide a free directory enquiry service to blind people and other disabled people who are unable to use a phone book. Oftel's advice is for all those people entitled to receive this free service, to register with BT as soon as possible.

But, as TRR comments, this free service is already being abused. Apparently Barclays Bank has announced that it will be using 250 blind operators to make its DQ calls. "Gritting its corporate teeth, BT declared that it was 'delighted' to be able to improve

The entire BT telephone directory is now available on optical disk, information can be displayed on a suitably equipped PC.

blind people's prospects in this manner, but clearly this was not quite what it had in mind when it offered free DQs to the blind".

From BT's viewpoint, as expressed by their vice-chairman, Mike Bett: "The £250 million cost of providing the directory enquiry service has been borne by every customer through higher call charges whether they use the service or not". He adds that everybody would benefit from the new lower call charges. "It is much fairer that those who use the directory enquiry service should pay for it, enabling call charges to be reduced for everybody, including those customers who rarely use the service".

He further stresses that there would be no extra revenue for the company. "Every penny made from charging is going back to our customers through the lower call charges".

There can be no doubt about it, products such as the Casio Digital Diary, which can hold and sort up to 3,000 telephone numbers (see the 1992 Maplin Catalogue), will be in great demand. Meantime, ET would be well advised not to 'phone home unless he already knows the number, though whether the BT operator would be able to source extra terrestrial numbers is somewhat open to doubt. The 'Telecomms Regulation Review' can be contacted on 0422 330340.

'Box Format Material'

Blind and disabled people not able to use a telephone book can still enjoy a free directory enquiry service. This service will be run from a purpose-built £10.5 million centre in Sheffield, and will eventually employ 500 people operating 200 VDUs linked to an £8 million computer system. Callers who, through blindness, dyslexia or inability to open or hold a 'phone book, are eligible for the free service.

Registration is made by completing an application form, certified by a district nurse or social worker, and then the applicant is sent a two-letter, four digit Personal Identification Number. The information is in large print for partially sighted customers, Braille cards are also available. Directory Enquiry calls from card-holders are made by calling 195. When this call comes through, the operator will punch a terminal key to access the free-call register. As far as possible, disabled staff are employed at the exchange.

LOCAL AND NATIONAL DIALLED CALLS — ANNEX A

		CURRENT	NEW
UNIT FEE (excl VAT):		4.4p	**4.2p**
TIME ALLOWED IN SECONDS FOR EACH UNIT FEE			
Local	Peak	60	**60**
	Standard	85	**85**
	Cheap	240	**240**
National (a)	Peak	26.25	**27**
(up to 56·4km)	Standard	35.1	**36.15**
	Cheap	81.8	**85.25**
National (b1)	Peak	23.25	**23.95**
(over 56·4km	Standard	31	**32**
low cost routes)	Cheap	51.5	**53**
National (b)	Peak	18.6	**19.2**
(over 56·4km & to Channel	Standard	24.8	**25.6**
Islands and Isle of Man	Cheap	38.8	**39.9**
'm' rate	Peak	8	**7.61**
(calls to mobile phones)	Standard	8	**7.61**
	Cheap	12	**11.4**
Callstream	Peak	6.9	**6.59**
(0898)	Standard	6.9	**6.59**
	Cheap	9.2	**8.79**
Irish Republic	Peak	8	**8**
	Standard	8	**8**
	Cheap	10.8	**10.8**

Peak rate – Mon-Fri 09.00-13.00
Standard rate – Mon-Fri 08.00-09.00 and 13.00-18.00
Cheap rate – Mon-Fri 18.00-08.00 and all weekend

Microphones Continued from page 39

Microphones for Music

Professional recording engineers have a range of different microphones which they use to get desirable (and often arcane) artistic effects on different instruments. While I would not suggest that you close-mic a kick-drum with a high-output electret microphone, because you will overload the preamplifier, you can make quite good stereo recordings, of folk music soloists and groups for example, with an inexpensive pair of cardioid electrets (YK64U), mounted as a 'coincident pair' as shown in Figure 3, from 1 to 2 metres from the artists in a normal room, even a living room. These microphones have a basic wide, flat frequency response, and the coincident pair gives sharp, unambiguous directional information. Personally, I have had less satisfactory results with separated microphones, but some professional recording engineers (which I am not) use nothing else. More complex multi-microphone techniques are not governed by general rules, and their successful use is based largely on experience.

Directional Response

A small, simple microphone, having the sensitive element (normally a diaphragm) exposed to sound only on one side, has a basically omnidirectional response, i.e. it produces the same output from whatever direction the sound is coming. In three dimensions, the directional response is spherical, except for the inevitable disturbance caused at high frequencies by the obstruction formed by the body of the microphone itself. Normally, two-dimensional directional responses are specified, in the horizontal and vertical planes. For an omnidirectional microphone with the axis vertical, the horizontal directional response is a circle, while the vertical response shows the obstruction effect, as shown in Figure 4. The protective grille and casing of a practical microphone tend to degrade the perfection of these responses. An omnidirectional microphone responds to the pressure of the sound waves, and is therefore called a pressure microphone. Because they respond nearly equally in all directions, omnidirectional microphones are particularly good at picking up unwanted noise and reverberation. Used with care, however, they produce very good results.

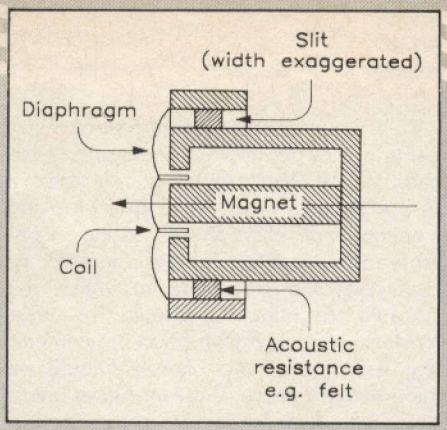


Figure 7. Basic construction of a cardioid dynamic microphone capsule.

Open at Both Ends

A microphone which has *both* sides of the diaphragm (or equivalent) exposed to the sound wave responds to the particle velocity of the sound waves, and has a directional response like a 'figure-eight', as shown in Figure 5. On a linear (voltage) scale of output, this response consists of two circles (Figure 5a), but the normal practice is to use a decibel scale, which results in a 'squashed' shape (Figure 5b). Ribbon and capacitor microphones can be made as velocity microphones, indeed, most ribbon microphones are of this type.

Another type of microphone having a similar directional response is the pressure-gradient microphone. Here, two pressure microphones are arranged, one close behind the other, and their outputs subtracted. This is not an inexpensive arrangement, and obstruction effects can be severe at high frequencies.

Cardioid Microphones

I prefer this term to 'unidirectional', because the microphone doesn't respond in only one direction, but, to some extent, in *every* direction *but* one. 'Cardioid' means 'heart-shaped', as can be seen from Figure 6. Curiously, the cardioid shape is not much distorted by the decibel scaling.

Cardioid microphones are overall the most useful for general applications. They are much less sensitive to unwanted noise and reverberation than omnidirectional microphones. This property is conveniently expressed by saying that for equal relative reverberation pick-up, a cardioid microphone can be 1·7 times as far away from the talker as an omnidirectional microphone. More extreme (narrower) directional responses can only improve this figure to about twice as far.

The cardioid response can be achieved by adding the outputs of an omnidirectional microphone and a 'figure-eight' microphone, but is usually produced by exposing one side of a diaphragm directly to the sound, while the other side is exposed through an acoustic phase-shift. This is usually formed by a slit, or series thereof (acoustic mass, equivalent to inductance), with some damping (acoustic resistance) added (Figure 7). Achieving the necessary phase-shift over a wide frequency range, and consistently in production, is definitely still an art.

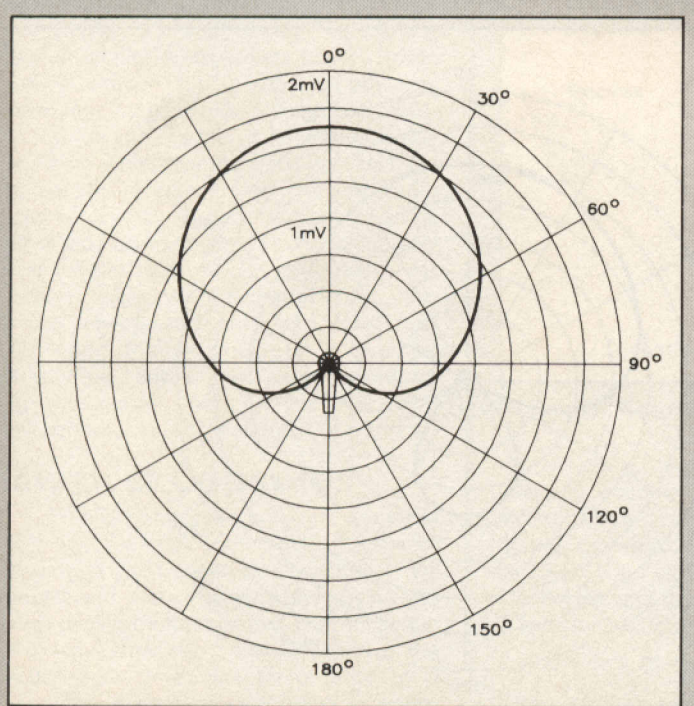


Figure 6a. Directional response of a cardioid microphone: linear output voltage scale.

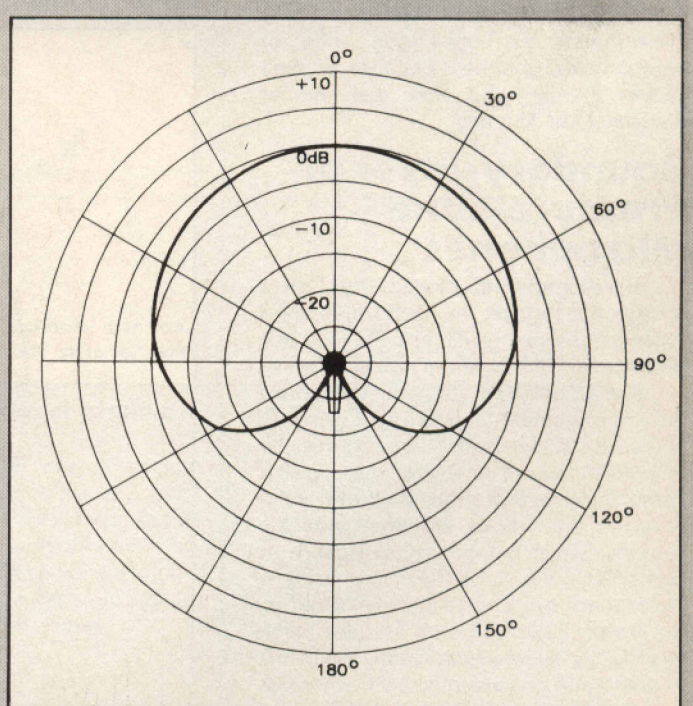


Figure 6b. Directional response of a cardioid microphone: output presented on a decibel scale.

Cardioid Derivatives

By massaging the relative sensitivities of the two sides of the diaphragm, derivatives of the cardioid can be made. These have non-zero response around the 180° direction, but less response to the sides (Figure 8). Effectively, these responses are produced by adding an omnidirectional response to a larger 'figure-eight' response, and by varying the amount of 'figure-eight' response, one can obtain any shape from a circle to a cardioid. Two identifiable responses from this continuum are the 'hypercardioid', which has the minimum achievable response to reverberant signals of all the family, and the 'supercardioid', which has the greatest ratio of axial to random sensitivity of all the family.

Highly-directional Microphones

By attaching a microphone to the end of a suitable wave-interference structure, a very narrow directional response can be obtained. The basic structure resembles a tin whistle (a tapered tube with a line of holes in the wall), with the microphone attached to the large end. It can be shown that sound waves arriving at more than a small angle to the axis of the tube suffer destructive cancellation as they travel down the tube, and therefore produce no response from the microphone. The response is similar to a cardioid if the tube is half a wavelength long, and progressively narrows as the wavelength decreases (frequency increases). So to get even a cardioid characteristic at 20Hz demands a tube 8·5m long. Clearly, a practical microphone of this type is directional only at higher frequencies. Alternative wave-interference structures include a series of narrow tubes of graded length (like Pan-pipes rolled up), and a tapered tube with a narrow lengthwise slot. Such microphones are called 'gun', 'rifle' or 'shotgun' microphones, because of their shape. People who find such names distasteful use 'line mic'.

Boundary-layer or Pressure-zone Microphones

If a microphone is placed very close to a large flat surface, the sound pressure it receives is twice that in the sound field at a distance from the boundary, so its effective sensitivity is doubled. This is the situation in the arrangement shown in Figure 2. Furthermore, whereas in free space the three-dimensional directional response is a complete sphere or other solid of revolution, the flat surface eliminates half the response, reducing it to a hemisphere or half solid. Effectively, the microphone is made much more directional (thus reducing reverberation pick-up), besides being less visually evident and possibly less prone to damage. Consequently, such 'boundary layer' or 'pressure zone' microphones are now very popular for most purposes, except perhaps communications.

It is quite easy to make one of these, using any of the microphone inserts in the magnificent Maplin Catalogue, whereas it is not so easy to make a good-looking conventional microphone casing. Contrary to many of the designs commercially available, the baseplate to which the capsule is attached should be *thin*. Preferably, it should be of an unsymmetrical shape, and the capsule should be mounted off-centre. These measures give a smoother high-frequency response. An omnidirectional capsule can be mounted facing the plate, with the sound entry about 1mm from the plate (Figure 9a), but a cardioid capsule (QY63T) should be mounted with its axis parallel to the plate and somewhat recessed into it (Figure 9b). It must be stressed that the baseplate has to stand on a table or be attached to a wall, ceiling or floor for the system to work properly.

Transducer Principles

That impressive (?) heading means 'how sound energy is converted to electrical energy'. Dynamic microphones use an electromagnetic arrangement like a moving-coil loudspeaker (Figure 3). In fact, loudspeakers can make excellent microphones, and not only for intercoms and

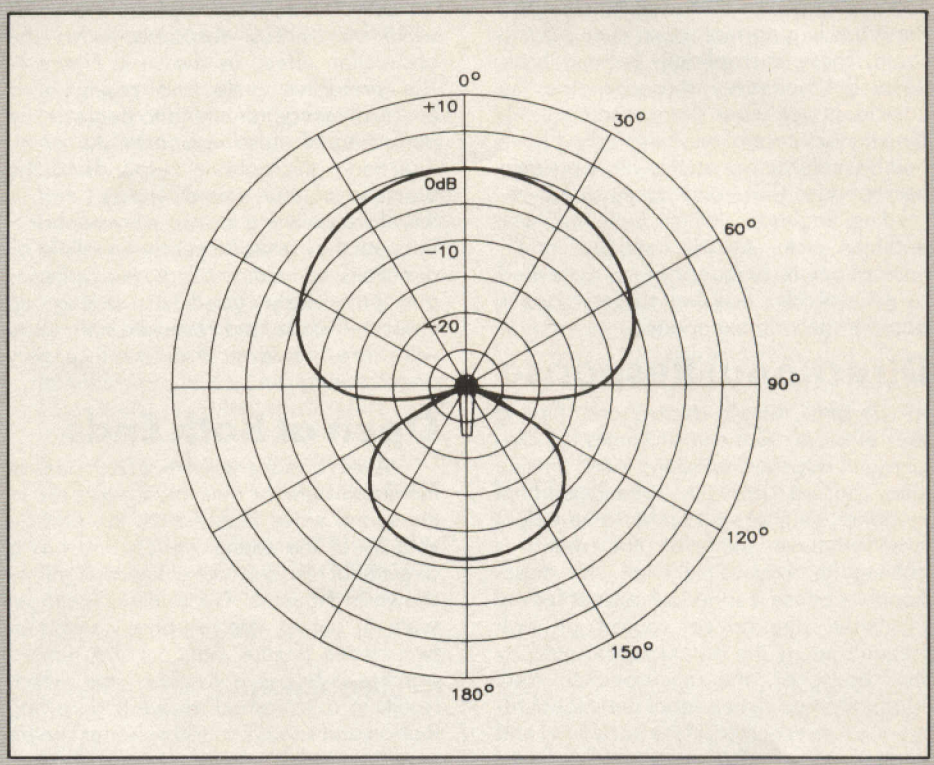


Figure 8a. Directional response of a hypercardioid microphone: decibel scale.

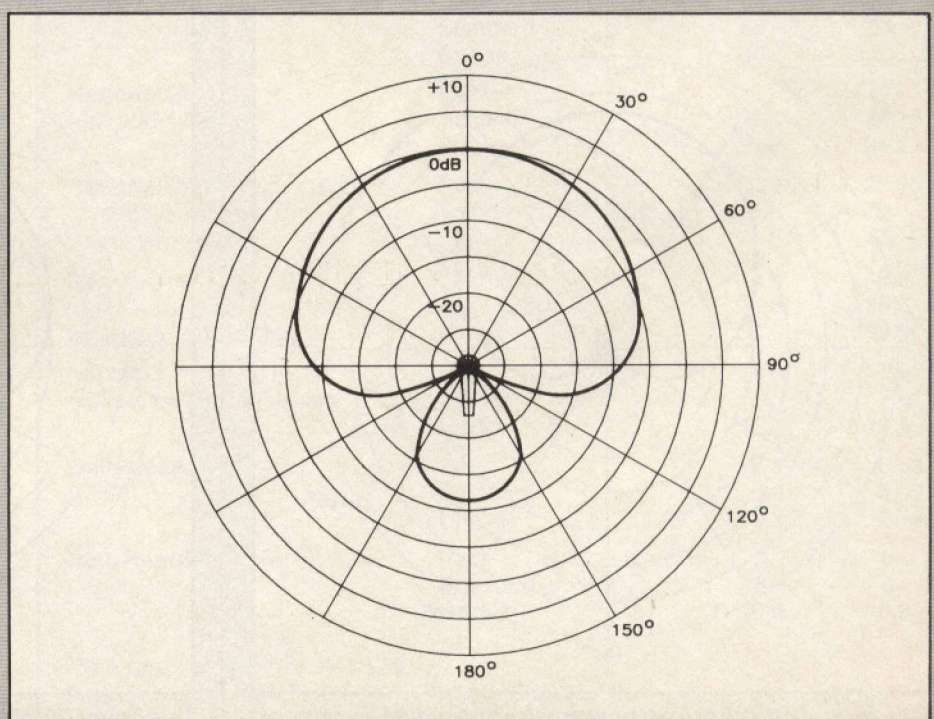


Figure 8b. Directional response of a supercardioid microphone: decibel scale.

suchlike applications where both a microphone and a loudspeaker are required. Limitations on wire diameter for the moving coil mean that the coil impedance is limited to a maximum value of about 200Ω. High impedance dynamic microphones have a built-in transformer.

Dynamic microphone capsules normally have a diaphragm designed so that the reactance of its acoustic stiffness (reciprocal of compliance) is much greater than the reactance of its acoustic mass or its acoustic resistance. This basically gives a flat frequency response into a high-impedance electrical load. A loudspeaker, however, has a diaphragm whose acoustic mass is the controlling impedance above the bass resonance frequency. Consequently, if fed into a higher impedance load, as for a normal microphone, its frequency response is not at all good. Some 12 years ago, Peter Baxandall developed the proper way to use loudspeakers as microphones, and the following is adapted from his paper delivered at the 65th Audio Engineering Society Convention in London (Preprint No. 1593, available from AES British Section, Lent Rise Road, Burnham, Slough, SL1 7NY, for money). Any errors in the adaptation are entirely mine.

The way to get a flat frequency response is to feed the loudspeaker into a very low impedance and then introduce equalization rising at 6dB/octave. A very simple way of doing this is to use a ferrite-core transformer. I have not been able to try this with Maplin components, but it seems very likely that one of the miniature 64Ω loudspeakers could be used, connected to the primary winding of the Ionizer Transformer JL94C, with the secondary winding connected to a high-impedance input of a preamplifier. Two 10Ω resistors should be connected in series across the primary terminals and their centre-point earthed. The circuit could also be satisfactory with lower impedance, higher quality loudspeakers, but this has to be a matter for future experiments. Magnetic screening is unnecessary, provided the transformer is kept reasonably far from mains transformers, but electrical screening is essential to prevent radio pick-up. Even with good screening, an r.f. filter may be necessary on the secondary side. Peter Baxandall's preprint gives several more sophisticated circuits, with much better performance, and many ideas for using this technique. It should be emphasised that a good loudspeaker can give as good results in this way as a microphone costing hundreds of pounds.

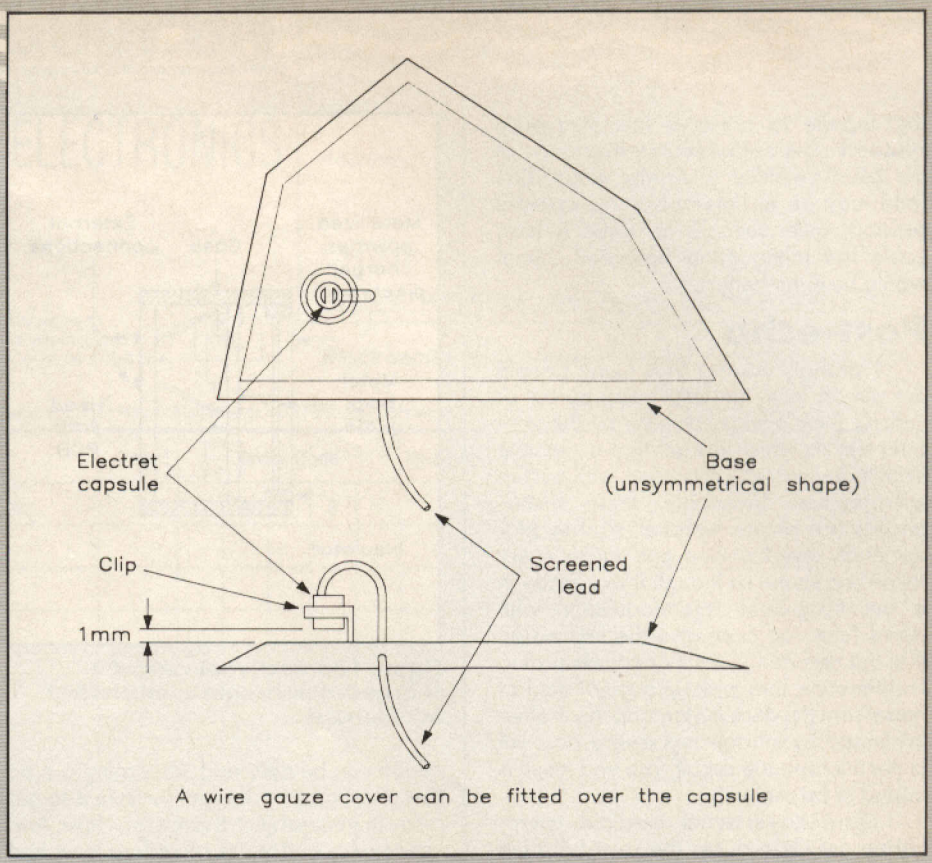


Figure 9a. Boundary layer omni microphone.

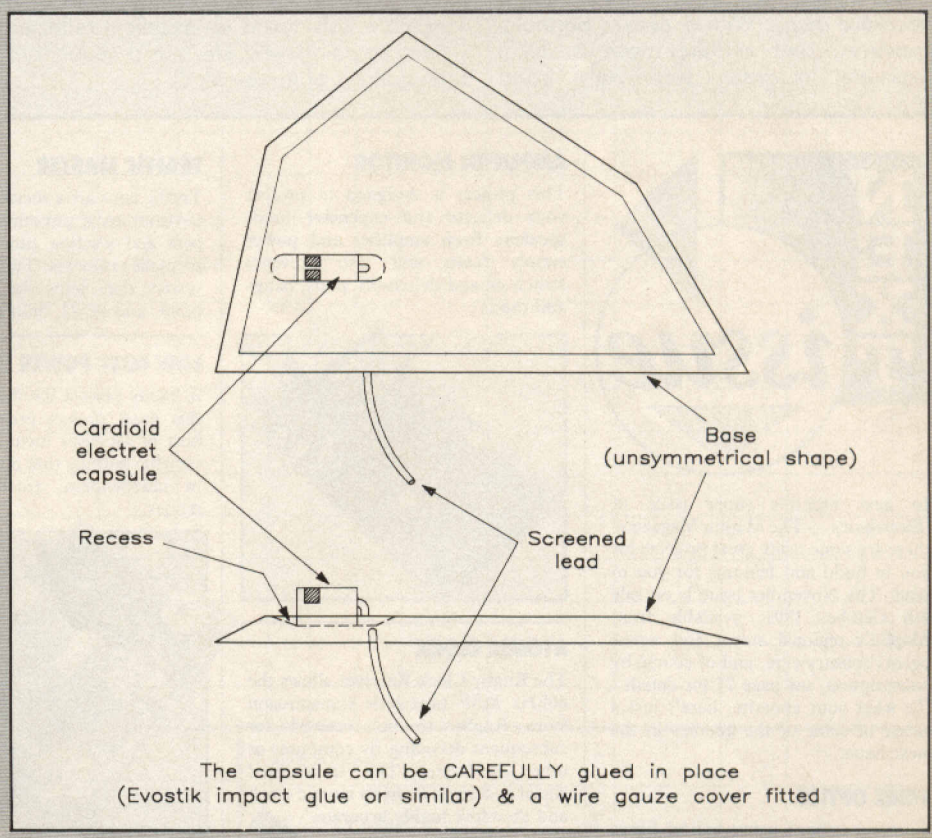

Cardioid electret capsule
Base (unsymmetrical shape)
Recess
Screened lead
The capsule can be CAREFULLY glued in place
(Evostik impact glue or similar) & a wire gauze cover fitted

Figure 9b. Boundary layer cardioid microphone.

Electret Capsules

While permanent magnets are quite familiar, the idea of a block of material having a permanent electric charge still seems odd. Nevertheless, polymers such as polyvinylidene fluoride can be charged in this way. They can be used either as the diaphragm or as the fixed plate of a capacitor microphone, as shown in Figure 10. The permanent electret keeps the capacitor permanently charged. It does not act as a continuous energy source (shame!) because there is no DC path through it; it is a very good insulator. As the diaphragm vibrates in sympathy with the incident sound wave, the spacing d of the electrodes, and therefore the capacitance C (picofarads, in practice), varies:

$$C = (\epsilon \times A) \div d$$

where ϵ is the permittivity ($10^{-9} \div (36 \times \pi) = 8{\cdot}9 pFm^{-1}$) and A is the area of the electrode (m^2).

Since the electric charge Q (coulombs) is fixed, the voltage V to which the capacitor is charged is:

$$V = Q \div C = (Q \times d) \div (\epsilon \times A)$$

The voltage is thus proportional to the distance d, so that the sound signal is converted to voltage without distortion. Because the capacitance of the capsule is so low (typically 10pF to 30pF), a FET head amplifier with an input resistance typically of 1GΩ (a thousand megohms) is built into

the capsule to preserve low frequency response. The output source resistance of the head amplifier is usually about 1kΩ (and may be an internal or an external resistor), quite suitable for even a long cable run (although a balanced output would be even better).

Post-echo

I strongly suspect that many people are put off from the fascinating pursuit of making their own recordings by the very poor results which are all that is possible from many cassette recorders with built-in microphones. Invariably, these microphones are omnidirectional, so they pick up much reverberation and make every recording sound as though it was made in a swimming-pool. Intermodulation with mains hum can even give the impression that the recording was made underwater. Furthermore, they pick up a great deal of noise from the deck motor, and this is often minimised by introducing severe bass-cut in the microphone circuit. The end result is bound to be useless!

Using an external cardioid microphone greatly reduces the reverberation problem, and eliminates the motor noise. Mains hum is best cured by throwing the recorder away. With a decent portable, however, and certainly with a 'Hi-Fi separate' recorder, surprisingly good results can be obtained. Recording is a bit like photography: the golden rule is to get close to your subject, but not too close. And automatic controls (of recording level and exposure) work well 90% of the time but occasionally let you down. Finally, a satellite dish makes an excellent reflector for recording wild life, but a redundant Squarial is of no use at all.

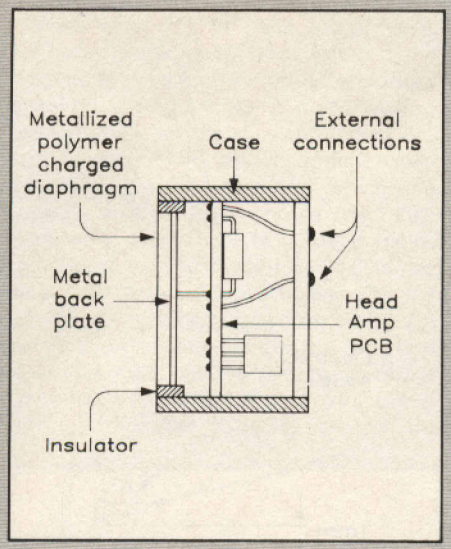


Figure 10a. Sectional view of a charged-diaphragm omni electret microphone.

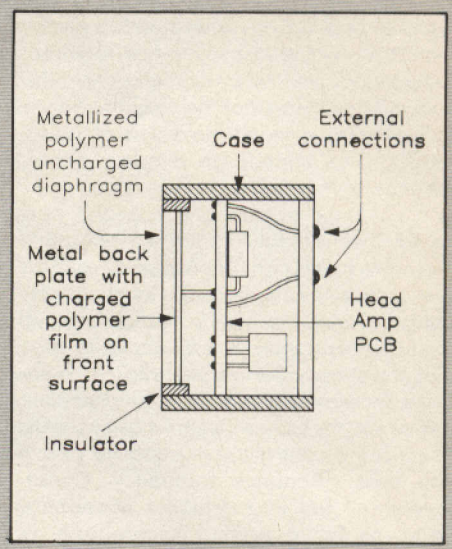


Figure 10b. Sectional view of a charged-backplate omni electret microphone.

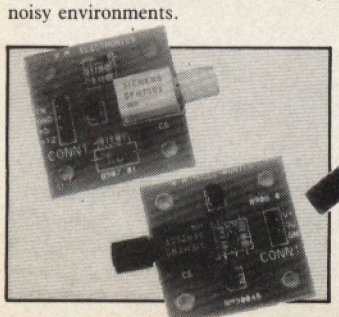
Don't miss the next super issue!
On sale – 4th October 1991

NEXT issue

In next month's super issue of 'Electronics — The Maplin Magazine' there are some really great projects for you to build and features for you to read. The November issue is on sale 4th October 1991, available from Maplin's regional stores and newsagents countrywide, and of course by subscription, see page 75 for details. To whet your appetite, here's just a taster of some of the goodies in the next issue:

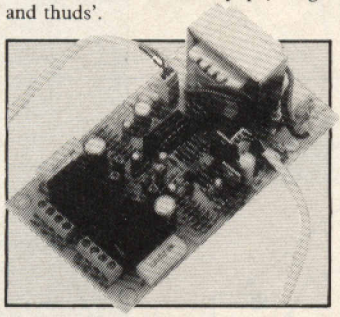
FIBRE OPTICS

Communications using optical fibres is made possible with the Fibre-Optic Digital Link — applications include serial communications in electrically noisy environments.



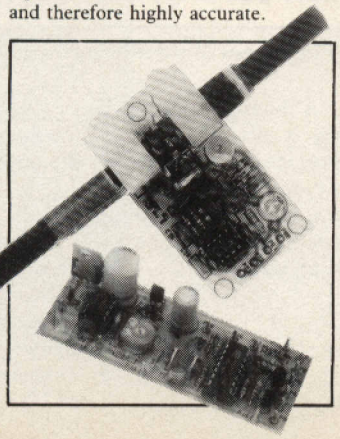
AMPLIFIER MONITOR

This project is designed to protect your delicate and expensive loudspeakers from amplifier and power supply faults and also prevents switch-on and switch-off 'pops, bangs and thuds'.



ATOMIC CLOCK

The Rugby Clock Receiver allows the 60kHz MSF time-code transmission from Rugby to be received for subsequent decoding by computer or other hardware. The transmitted signal is derived from an atomic clock and therefore highly accurate.



TRAFFIC MASTER

Traffic jams are a social, business and environmental nuisance; raising tempers and wasting time, money and precious resources. Traffic Master is a system that helps the traveller pinpoint, and avoid, hold-ups.

LOW COST POWER SUPPLY

A handy project for the work-bench, this great project provides a whole host of facilities including two fully variable outputs that may be operated in independent, tracking or split modes.

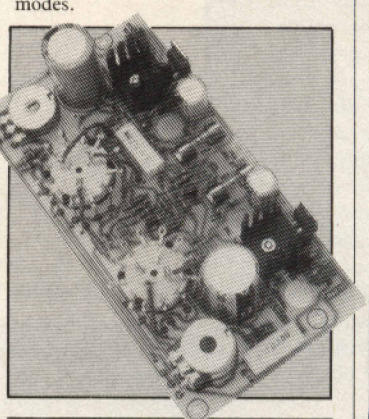
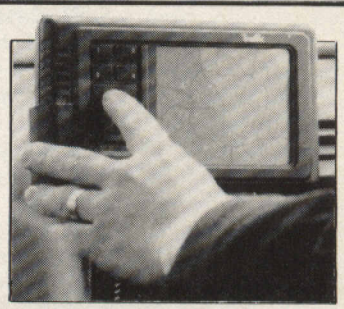


IMAGE PROCESSING

Increasingly it is becoming more attractive to manipulate text and images on computer instead of using paper, photographs and drawings.

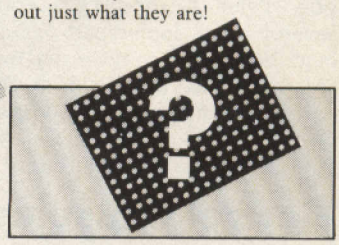


FRAME & FERRITE ROD ANTENNAS

How frame and ferrite rod antennas work is explained in this in-depth feature.

MINI CIRCUITS

Bob Penfold returns by popular demand with more of his Mini Circuits — you'll have to wait to find out just what they are!



COMPETITION

Win free entry to the Science Museum for a whole year!

Plus of course there's all the usual regulars for you to enjoy!

'ELECTRONICS – THE MAPLIN MAGAZINE'

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

HEARING, DEAFNESS and ELECTRONIC TECHNOLOGY

Part Four – Sound Advantage
by Alan Simpson

Foreword

The following article, which is the fourth and final part in a series on Hearing, Deafness and Electronic Technology, takes a look at how BT and the RNID are providing easy access to modern communications technology. It is hoped that it will encourage people to accept deafness as a part of life, and encourage positive thinking and action to help deaf people to integrate with society as a whole. Every person, whether deaf or hearing, has a vital role in today's world, each with their own, totally unique, contribution.

Introduction

Communication technology is coming to the aid of the disabled. Information technology systems developed for the business user are being adapted to meet the needs of the disabled or handicapped person. Highlighted technologies include digital communications, scanners, voice synthesisers and character recognition techniques. Also expected to play a key role in helping the lives of the deaf and the blind is the application of intelligent or expert systems.

For most of us, using the telephone is second nature. It is our link to living in the 20th century. But for someone who is hard of hearing, using a phone is often a traumatic experience, one to be viewed with fear and trepidation. For the totally deaf of course, the standard-issue telephone is a no go-area, and even specially amplified booster equipment provided by British Telecom can do little to help.

Deafness is Not Understood

However, as Jack Ashley, the Labour MP who himself suffers from deafness says "Blindness receives universal sympathy, but deafness is not even understood. As a result, most deaf people have to work extra hard at overcoming their handicap". Jack Ashley, who is president of 'The Hearing Research Trust', believes that deafness research is phenomenally under-funded.

Community Care

While BT attracted much stick earlier this year, by spending a reputed £50 million plus on a new corporate logo, and acting as an enthusiastic collector of VAT for HM Customs and Excise, not much was heard about the other – the 'caring community' – side of the corporation. The BT Community Programme is driven by the company's mission statement, which pledges the company 'to make a fitting contribution to the community in which we conduct our business'.

In fact, BT is a member of the 'Per Cent Club of British Businesses', who undertake to give not less than half a per cent of UK generated pre-tax profit to the community. A major unit of the programme is 'Action for Disabled Customers', which looks after the special needs of disabled customers and produces the Blue Guide of telecommunication products and service for the disabled yearly.

For British Telecom, a company whose core business is speech, a highlight of the programme last year was the sponsorship of The National Speak Week. The aim of the project was to draw attention to the communications of an estimated 2.5 million people in the UK who have hearing problems, which are bad enough to be classified as a disability, while possibly some 7 or 8 million people have impaired hearing. (In comparison, 2,500,000 adults

are registered as blind or partially sighted in the UK, yet the income of the Royal National Institute for the Deaf [RNID] is only one third that of the Royal National Institute for the Blind.)

The problem for the deaf, reports BT, can often be brought about by disease, a stroke or an accident, and most sufferers have no other disability. Yet they are often treated with intolerance and impatience. To help support the week, a video was produced by the Spitting Image team, to encourage people working in retail services to be more aware of customers with communications difficulties. The video, called 'Everyday', focuses on four people who have successfully dealt with their telecommunications needs using a variety of solutions, including control equipment and equipment developed for special needs, the RNID exchange and the experimental videophone.

The Plight of the Deaf Telephone User

A major research study covering the plight of the deaf telephone user called 'Poor Connections', undertaken by The University of York and funded by the Department of Health, states that more than eight out of ten households in Britain have a telephone, yet most deaf people are excluded from the social benefits. "It is hard to keep in touch with family and friends; making appointments and contacting the bank, gas board, garage or local council, has to be done face-to-face or by letter; help lines, information services and telephone enquiries are out of reach.

"Employment opportunities are also affected: with the lack of a telephone that they can use, the kind of work deaf people can get is limited, as are their prospects when in a job.

"Most deaf people", the Report suggests "feel a strong sense of injustice, as they see telephone services for hearing people such as cellphones, car telephones and radio paging developing rapidly, while their own basic needs remain un-met". However a year or so earlier, the RNID had commissioned a report with the object of finding a way of increasing the desperately needed revenues.

A somewhat dramatic recommendation emerged that a commercial marketing company should be set up to serve deaf people, with profits going to the Institute.

Sound Advantage

As the RNID was already closely working with BT, the corporation was invited to get involved. As a result, a senior member of staff was given a six months secondment to produce a business plan. Secondment in fact is a major part of BT's support for the community. Working mainly in the field of job creation, or in industry/education partnerships, secondees provide practical help for the health of the community and of the wider business environment. This secondment of staff is seen as an integral part of BT's company policy, with mutual benefits and challenges arising. Everyone, the corporation says, benefits from secondment – the community, the company and the employees, who are seen very much as 'ambassadors', applying and developing their professional expertise to the benefit of all parties.

Following the production of the report, which found the idea fully feasible, he was given a further secondment period plus a commitment to invest a large sum of money from the RNID. As a result a new company was formed – Sound Advantage – located in a trading estate in Peterborough.

Sound Advantage has three key tasks. To see how well the needs of people with hearing problems are met by the wide range of devices and facilities that are already available, everything from telephone attachments and signing teddybears to flashing doorbells, and secondly, to liaise closely with the many suppliers and, of course, to ensure the business becomes profitable to help the RNID funds. The Sound Advantage format, that of one-stop shopping, means that for the very first time customers can obtain a whole range of products from a single source of contact.

Product Guide

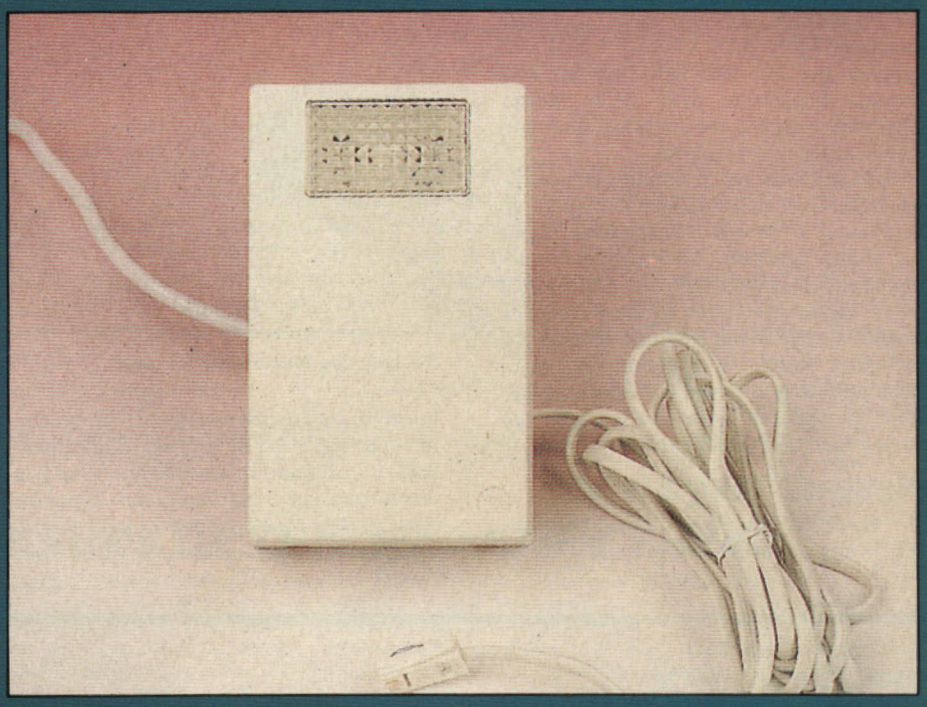
As may be expected, the Sound Advantage product guide features the very latest in high technology developments. Telecommunication items include Text Telephones – these allow deaf people to communicate over the public telephone network, by means of a keyboard and incorporated screen, where the costs starts at about £100.

Somewhat higher up the affordable scale at about £250 are desktop text telephones which feature a typewriter style keyboard and 8 line × 40 character display screen. More basic items are audio telephones which incorporate extra amplification, and/or an inductive coupler to improve clarity and reduce background noise for those with hearing aids. Also on sale are vibrating message pagers, answering and facsimile machines. A more advanced product is the only VCR which allows recording of teletext subtitles in colour. Other items in the development pipeline include an integrated alarm system and a series of lip reading videos.

Not, perhaps, in the 'high tech' development class, but none-the-less a best seller, is a cute teddy bear, designed to help deaf children learn sign language, whose arms have been replaced by sleeves.

Whether the teddy bear was used at the Palace Theatre, Westcliff, Essex and during the feast of Furness Festival in Cumbria for the recent BT sponsorship of

This VCR allows teletext subtitles to be recorded along with the normal TV picture and sound track.



This mains powered telephone indicator unit plugs into a conventional telephone socket and indicates an incoming call by emitting a high intensity light.

sign language in the theatre, is not known. But the initiative was certainly a success, with many deaf people present following the signing and laughing along with the rest of the audience.

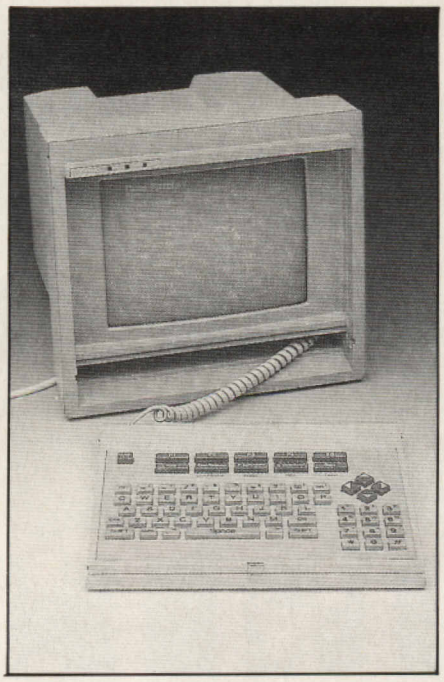
EM to Assist The Deaf

Electronic Mail is also helping UK children with speech impediments to communicate. A system called Chatback, which uses PCs linked to BT's Prestel E-Mail service, gives severely speech-impaired children the power to communicate. Children normally send Chatback messages from their school, which also supplies the PC, although children with serious disabilities work from home. Chatback supplies the mailbox, the software and technical support.

At the same time, a talking telephone has been developed by BT in Liverpool, to help take the fear out of hospital treatment for young children. The 'Garfield' telephone is linked to a tape recorder, which allows children to listen to their favourite stories, as they travel from the ward to the operating theatre. The phone stays with them until they are anaesthetised. It is also used by children with cancer, who are having radiation treatment.

National Relay Service

As reported in 'Electronics' last year, BT is providing £4 million, in a major initiative, to provide a national relay service for deaf and hard of hearing. This allows users to make and receive telephone calls in text format on a computer screen. Using the service, speech is converted by an RNID operator into text, and then the typed reply is read to hearing people using an ordinary phone. Alternatively, a deaf person with good speech can talk directly to a hearing person but receives replies in text, prepared by the RNID operator.



Desktop Communications terminal.

Now this relay service is being extended by the opening of a new nation-wide telephone exchange for deaf people, in a £4 million project funded by BT. Again run by the RNID with support from BT, the exchange will start with 30 operators and will run 24 hours a day, compared with the existing exchange with just 3 operators and a capacity for only 170 customers. BT's new Meridian digital switching system will handle callers, queuing them automatically and putting them through to the next free operator.

Just in case the BT care message does not get through, BT ensure that those of their shareholders who are deaf or hard of hearing are directed to a special area at the Annual General Meeting. Here induction loops will be available for those with hearing aids, while for others there will be a sign language facility.

A free guide to the BT equipment and services which make it easier for disabled people to use the telephone, is available from all BT sales offices, or by calling the operator and asking for Freefone Telecom Sales. Sound Advantage can be contacted on (0733) 361199, fax: (0733) 361161, minicom (0733) 238020.

CIRCUIT MAKER

Circuit Maker is a forum for readers' circuits, ideas and tips. The circuits and information presented here must be considered as a basis for your own experimentation, no warranty is given for suitability in particular applications, reliability or circuit operation. Maplin cannot support, in any way, the information presented here. However, where possible, we will endeavour to check that information presented, is correct, and that circuits will function as stated.

Dan Dare Super Space age Torch by Ben Sullivan

Here's a super high-efficiency high tech torch. It throws a beam about as bright as a 3·5V 150mA lens-end torch bulb (albeit red, not 'white'), but it only consumes some 50mA. So whereas the bulb would run a 500mAh Ni-Cd pack flat in a couple of hours, at most, this torch will see you through 10 hours on one charge. Its improved economy is even more important if using a primary (non-rechargeable) cell such as manganese-alkaline type.

The circuit is exceedingly simple, basically a flyback converter or, in olden parlance, a blocking oscillator. At switch-on, the forward bias via R1 causes the transistor to conduct, and the positive feed-back via the base winding of T1 then causes it to saturate. The collector current builds up at a rate determined by the inductance of the primary and the voltage of the battery, until, as the 10nF capacitor charges down below ground, there is no longer enough base current to support the collector current. The collector voltage therefore starts to rise and the positive feed-back results in the transistor being rapidly cut off at the base. The collector voltage flies up until clamped by the turn-on of the LED, i.e. at about +1·8V, and remains positive until the current through T1 primary has dropped almost to zero. At this time, the 10nF capacitor has recharged via R1 from its negative peak to about +0·6V, the transistor starts to turn on again and the cycle repeats. The circuit runs at about 20kHz and the fast switching times of the transistor used ensure that most of the energy drawn from the battery finishes up in the LED.

The circuit works best with a battery whose terminal voltage is fairly constant over its useful life, so Ni-Cd or alkaline cells are best, zinc-carbon types are not recommended. The value of R1 is chosen to suit the battery type, 1k2 for a 1·2V Ni-Cd or 2k7 for a 1·5V manganese-alkaline type. The transformer primary and secondary windings are 30-turns each of 32SWG EC wire wound on a 'Type 2' pot core, note the phasing of the windings indicated in the circuit. If the circuit doesn't work first-off, try reversing the connections to one of the windings. With a little ingenuity, the circuit can be built up into a very small, neat pocketable unit that either Dan or Scotty would be glad of.

RESISTORS: All 0·6W 1% Metal Film

R1	1k2	1	M1K
or	2k7	1	M2K7

CAPACITORS

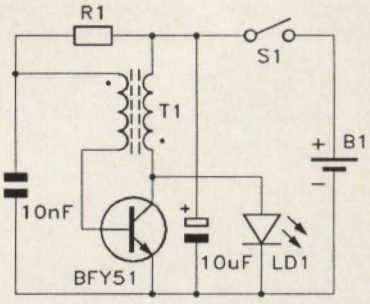
C1	10nF Ceramic	1	WX77J

SEMICONDUCTORS

LD1	Ultra-bright Red LED 8mm	1	UK24B
TR1	BFY51	1	QF28F

MISCELLANEOUS

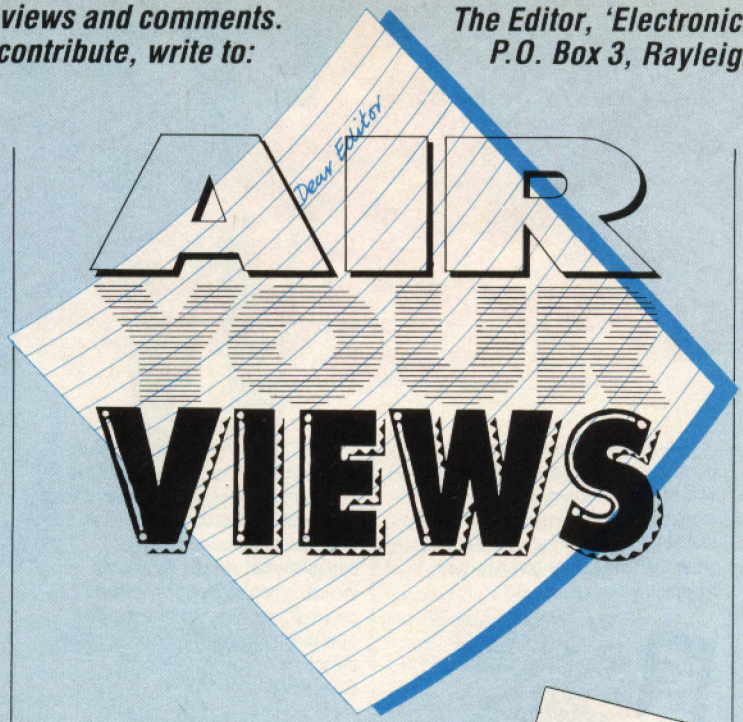
T1	Type 2 Pot Core	1	HX06G
	Type 2 Bobbin	1	HX07H
	Type 2 Clips	2	HX08J
	32 SWG EC Wire	1 reel	BL41U
	AA Battery Box	1	YR59P
	AA Ni-Cd Cell	1	YG00A
or	AA Alkaline Cell	1	FK64U
	SP Slide Switch	1	FF77J
or	Push Switch	1	FH59P
	Strip Board 1039	1	JP46A



V_S = 1.2V R_1 = 1k2
V_S = 1.5V R_1 = 2k7
T_1 – 30T + 30T 32 SWG ON LA4345 Pot Core

A readers forum for your views and comments. If you want to contribute, write to:

The Editor, 'Electronics – The Maplin Magazine' P.O. Box 3, Rayleigh, Essex, SS6 8LR.



Harmonic MIDI

Dear Sir,
I have a MIDI system comprising an Atari computer 520STFM and a Yamaha Porta Sound 680 keyboard. As I can play a harmonica rather well, what I should like to possess is a Harmonica-like instrument producing digital information only, which can be fed into my the MIDI system. What I would like to know is would a project like this be practicable.
R. Cobbet, Plymouth, Devon.

In principle the idea is perfectly feasible, a similar idea has been used in some add-on MIDI guitar systems. In essence, fourier analysis is used to ascertain what musical notes are being played, the information is then processed and used to generate MIDI note on and note off commands. The MIDI data is then used in the normal way to control synthesisers, etc. The fourier analysis is carried out by a digital signal processing IC and a microprocessor is used to interpret the information and generate the MIDI data. A harmonica equivalent would use a small microphone attached to the harmonica to pick-up the sound and the electronics would take over from there.

White LEDs

Dear Sir,
Could you please tell me if I can get a 3mm white LED, or don't they make them? I would like some for my model railway coaches. Also are there any books about photo diodes and photo transistors. I want some sort of beam so that when the train passes through the beam, a light will come on on my indicator board, so I know where the train is so I can stop it.
K. Hall, Coventry.

Unfortunately LEDs emit monochromatic light only, i.e. one colour. Since white light is 'made up' of a spectrum of colours, the LED is not of much help. However, it might be acceptable to use a yellow LED, which is about as near as you will get, the effect would be similar to a filament lamp being slightly under-run. There are quite a number of books that may be of interest, these may be found in the books section of our current catalogue, look under Opto Electronics. These would certainly contain the break-beam type circuits that you are looking for. An alternative is to use reed switches or hall effect sensors buried in the track and attach small magnets to the underside of the loco's. Two books that may be of particular interest are Model Railway Projects by R. A. Penfold (WG60Q) and Electronic Circuits for the Computer Control of Model Railways also by R. A. Penfold (WP71N).

S·T·A·R L·E·T·T·E·R

This issue, P. Adams from Bath, Avon, receives the Star Letter Award of a £5 Maplin Gift Token for his letter, on how to detect car battery overcharging.

Dear Sir,
I have built your very popular car battery monitor project. A simple adjustment can be made to the car battery monitor to make the project even better. By adjusting RV1 so that the top LED lights at 15V instead of 14V, you have an overcharging indication as well as an undercharging etc. Any auto-electrician will tell you, overcharging can be dangerous as well as a failed battery due to the regulator being faulty. This simple adjustment with a re-arrangement of colours makes great use of the car battery monitor project.

Ignition

Dear Sir,
I now like the look of the Maplin Magazine with some little circuits as well as major ones. Audio ear blasting stuff and trade hype leaves me cold so a reduction in this content is a step forward in my view. The main reason that I am writing is in connection with the Car Tachometer. To make the rev counter 'universal' for conventional and electronic ignition systems it is only necessary to pick up a pulse from one of the spark plugs. It can be done by using a split ferrite ring with 5 or 6 turns of wire or similar. For a diesel engine, a transducer on the injector pipe will also pick up the pulse. Whatever method is used, safety is paramount, therefore no direct connection can be made to any part of the electrical system, which could cause a failure of that system. An ignition failure on a crowded motorway is a recipe for disaster. At best, a failure means a misfire on one cylinder, at worst . . .
D. Briggs, Adman Services, Shropshire.

Switched Mode Power Supply Request

Dear Sirs,
I would like to take this opportunity to compliment you on your excellent magazine. I read with interest the series on switched mode power supplies, and decided I would like to build a unit that converts +12V DC to ±50V DC for use with the Maplin 150W MOSFET Amp Kit. As you were requesting suggestions on projects or applications for switched mode supplies, I thought I would put my idea forward. The total concept is to build a stereo 150W amplifier for the car. If my idea is not quite what you had in mind, then how about an article covering some of the aspects of designing our own units? (e.g. transformer design – do you use a ratio of, say, 50:200 or 100:400 and what gauge of wire? Keep up the excellent work.
D. T. Hunter AMIEIE ENGTECH, Longfield, Kent.

Look no further than page 16 of this issue for the answer to your question!

AFILS Help

Dear Sirs,
Your recent series of excellent written articles on AFILS would seem to provide the answer to our home entertainment problem. Whilst the NHS hearing aid (with T setting) does indeed lift volume, there is little or no clarity with so much of what is said lost, we were thinking this is a pleasure our advancing years would finally exclude. We look/listen via TV/VCR in a small room some 8ft. 9in. x 8ft. x 7ft. 6in. high and the VCR has an audio out which perhaps could contribute. However, I am not the experienced constructor your circuitry requires, and I wonder if Mr Woodgate could help me? I would gladly pay for his services.
J. Wright, Chelmsford, Essex.

John Woodgate Replies:
Your situation is ideally suited to help from a household induction loop system. I am arranging for you to receive details of commercially available systems, which cost roughly from £50 to £100 (no VAT payable). Such information can be obtained, for example, from the Royal National Institute for the Deaf, 105 Gower Street, London WC1E 6AH. I regret that I cannot supply you with one of my loop systems (which would, in any case, not cost less as a made-up 'one off', than a commercial system), because I am professionally involved in the electronics industry and the European Community product safety legislation (the Consumer Safety Act in the UK) would therefore, I understand, apply. This provides for the manufacturer of goods to be liable to an unlimited extent for any mishap which might be caused by the goods. Since I am not in business as a manufacturer, I do not carry the very expensive 'Product Liability Insurance' that would be necessary. The act and its penalties may not apply to the case where an amateur makes a 'one-off' for a friend, however I am not trained in the law and if anyone qualified would care to correct any of the above, that would be most helpful.

Odds and Ends

Dear Sir,
While reading the excellent new Maplin catalogue and the first edition of 'Digest', I noticed that in the description of the Electronic Roulette project, you have quoted the odds of landing on any one number on the roulette wheel as $9{\cdot}842112 \times 10^{39}$ to 1.
The correct odds of landing on a particular number of a 37 number roulette wheel, are in fact 36 to 1, I know – I work in a casino. Perhaps a case of too much knowledge . . . ?
G. D. Cohen, London.

Your VIEWS

Inside Advice

Dear Sir,
I am writing after reading your article on the Compuguard Car Alarm System. A fellow inmate who gets your mag. each month loans me his to read (eventually). I don't know much about the micro-controller used in your system but on reading parts 1 and 2, I came to the conclusion that the interconnecting table doesn't seem right and would surely blow a fuse! Could you check it out please, and if it is wrong print the right one.
As an alarm engineer from both sides of the 'field' I found your picture of the alarm fitted amusing! I would like to point out to your readers that whilst the Compuguard System seems to be very good, an alarm system (in a car or a house) is only as good as its warning device and inaccessibility. To site an alarm system under the bonnet is asking for trouble. OK, you might scare 'them' off the first time, but once 'they' know there's an alarm it's relatively simple to cut a large hole in the bonnet using sheet metal cutters or reach underneath the car and have access to the whole alarm system! A much better idea is to fit the control box inside the car, under the dash or seat, or in the boot, and to fit two sounders each with their own security loop and fit them where access is near impossible from the outside of the car. If the alarm system is fitted right, along the lines suggested, it won't be just a deterrent but nigh-on impossible to get past.
Name supplied, HM Prison, Dartmoor.

You are quite correct about the wiring connections being wrong, this being due to an incorrect drawing being printed. A corrigenda has already been printed in the February to March '91 issue of 'Electronics'; the instructions supplied with the kit have also been amended.

To CB or not to CB

Dear Sir,
I have bought your last two magazines as I am very interested in electronics especially radio. I think that most of your projects and kits are very good, even though some are a bit ambitious for me. But one thing I would like to have a go at making is a 40 channel CB set. As they are so expensive in the shops and I cannot afford one, maybe you could include one in one of your future magazines.
M. Prince, Brentwood, Essex.

The price of CB equipment has remained largely static over the past ten years, so taking into account inflation, prices in real terms have actually fallen. In any case, it is doubtful if it would be possible to produce a kit for less than the current retail prices. A lot of expensive equipment would also be required to set-up the unit (i.e. spectrum analyser, oscilloscope, frequency counter, etc.) A more important reason why we cannot produce a kit for a CB is the Wireless Telegraphy Act, which requires radio transceivers to be approved, it is extremely doubtful as to whether the DTI would grant approval for such a kit. The best advice is to look around for a second-hand 'rig', these can be picked-up for around £25 to £35 depending on condition and facilities.

Mag-nificent

Dear Sir,
I am just writing to thank you for the Dec-Jan issue of the Maplin Magazine, which you sent to me recently following my comment on a return slip (which was primarily concerned with something else). I was surprised and delighted to find it lying on the doormat one morning. This goes to show how much you care about your customers, not only as a whole but individually (unlike some organisations) and I would like to say that I appreciate this immensely. I can firmly recommend Maplin to anyone who enjoys electronics as a hobby (or even those who don't yet!). Coupled with an excellent customer service are excellent prices, which are a major concern to the hobbyist with limited resources. I hope you continue to expand your chain of shops, especially in the Medway Town area.
T. P. Field, Gillingham, Kent.

Print and PCBs

Dear Sir,
Having been a reader of your magazine for some time now, I would like to make a few points if I may.
Please don't put the text for your articles on a colour background, or for that matter put patterns behind the text. Perhaps it's my ageing eyes, but it makes them very difficult ro read.
I noticed that on the PCB layouts you have stopped putting the drill holes, why? I used to copy the layout onto overhead projector film and print directly onto photo-resist sprayed boards. I now have to put all the dots back in.
On another subject altogether, the IBM PIO expansion for a PC, where is the PCB layout for this board? Finally, I would like your assistance. For years now I have been producing PCBs but have not been able to put the legends on the surface of the boards. I now use a computer to produce the layouts which can also create the silk screen layer as well. How can I transfer this image to the PCB?
D. Adcock, Leeds

We are taking greater care with the colour pages to avoid some of the nasties that have occurred in the past. We'll get it right in the end with a good balance of colour and clarity.
Regarding 'the case of the missing PCB drill holes' the answer is quite simply that our PCB manufacturers have specifically requested that we do not have holes in the PCB pads, as it reduces the service life of their drill bits. Since we print the same master artwork in the magazine as we supply to our PCB manufacturers, there are no holes, sorry! The PCB track-work for the IBM PIO card is not given as this PCB is a double-sided plated-through-hole PCB with a gold-plated edge connector and therefore we feel that the PCB is unsuitable for producing at home. Our prototype PCBs are made in-house by a PCB prototyping system made by Versatronics (perhaps we will publish an article on it some time!), this handles etch-resist, drilling, routing and legend direct from the disk files produced by our PCB CAD software, however, it is fairly expensive. If any readers have suggestions on how to transfer a silk screen legend to a PCB cheaply, please write in.

Read, Black and Blue

Dear Sir,
I heartily agree with H. Tyson ('Electronics' April to May '91). I find it very difficult to read the order codes and prices, in fact sometimes I have to use a magnifying glass. Please, next time, can they be in black.
R. W. Brayne, Peacehaven, East Sussex.

Since publication of last year's catalogue we have received a number of letters on the subject of red order codes and prices. The opinion seems to be that red does highlight the information, as was originally intended, but some people have problems with reading red print easily. It has therefore been decided that the order codes and prices in the 1992 Maplin Catalogue will be printed in blue. It is hoped that this will alleviate the problems that some people have encountered.

Weather Genlock or Not

Dear Sir,
Am I correct in saying, that the weathermen use a system called GENLOCK, to produce a picture of themselves 'on top of' the weather map? Am I also correct in saying, that this system is used to create certain special effects in films (i.e. Superman, to create the illusion of flying)? If so, I would like to know how much a system like this for home use would cost, and where I might be able to obtain such a system (preferably one which has SCART inputs/outputs), if at all possible please.
N. Irving, Farnham, Surrey.

Genlock plays an important role when video images are superimposed, but it is actually a process known as 'colour separation overlay' or 'chroma keying' that achieves this effect. Genlock is used to ensure that the two images are properly synchronised, otherwise one of the images will 'roll' horizontally and vertically. Feature films may use photographic effects or video effects, or even both to achieve flight sequences. The subject of video signals, systems and effects is very complex, but it will be dealt with in a future series, watch this space . . .

Sounds Great!

Dear Sir,
I was attracted by the High Quality Power Supply as I run an amplifier with similar power requirements. Mind you, I haven't been really happy with that amplifier for a while.
I adapted the design of the 'HQPSU' to my own amplifier – keeping the original transformer, using BYW 98-150 fast-recovery rectifiers, and 4700μF 63V audio grade cans. The difference has to be heard to be believed! On both full-range and bass guitar use, the sound is now punchy and clear. Even our drummer asked what I'd done to the amplifier!
I am now investigating replacing all the electrolytics in my equipment with low-ESR/low power factor alternatives, such has been the improvement already experienced.
Well done Mr Williamson – The HQPSU approach really works – when can we expect the speaker protection circuit?
J. M. Smith, Enfield, Middlesex.

Alan Williamson from the Lab. replies:
Thank you for your letter, it's nice to know our work is appreciated! The following suggestions may be of interest to you:
Coupling capacitors – All electrolytic capacitors should be removed from the signal path and replaced with high-quality non-polarised types, polypropylene, polystyrene or polyester layer. Very small capacitors <1nF should be replaced using silver mica. Bypass each capacitor with smaller value capacitors. Using polypropylene/polystyrene/ polyester types.
Decoupling capacitors – Wherever possible, replace small value electrolytic capacitors with tantalum types which perform better at high frequencies. Replace medium value electrolytics with tantalums if you can, otherwise use SMPS capacitors. Reservoir capacitors should be as large as practically possible, this is to minimise supply ripple.
The Amp Monitor (protection circuit) will be published in the November issue, on sale 4th October 1991, see page 70.

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